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Volume III

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THE USAF STABILITY AND CONTROL DIGITAL DATCOM
Volume III, Plot Module

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MCDONNELL DOUGLAS ASTRONAUTICS COMPANY — ST. LOUIS DIVISION
ST. LOUIS, MISSOURI 63166

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Final Report for Period August 1977 — November 1978

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This technical report has been reviewed and is approved for publication.


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program capabilities, input and output characteristics, and example problems. Volume II described program implementation of program implementation of Datcom methods. Volume III discusses a separate plot module for Digital Datcom.

The program is written in ANSI Fortran IV. The primary deviations from standard Fortran are Namelist input and certain statements required by the CDC compilers. Core requirements have been minimized by data packing and the use of overlays.

User oriented features of the program include minimized input requirements, input error analysis, and various options for application flexibility.

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FOREWORD

This report, "The USAF Stability and Control Digital Datcom," describes the computer program that calculates static stability, high lift and control, and dynamic derivative characteristics using the methods contained in Sections 4 through 7 of the USAF Stability and Control Datcom (revised April 1976). The report consists of the following three volumes:

- o Volume I, Users Manual
- o Volume II, Implementation of Datcom Methods
- o Volume III, Plot Module

A complete listing of the program is provided as a microfiche supplement.

This work was performed by the McDonnell Douglas Astronautics Company, Box 516, St. Louis, Missouri 63166, under contract number F33615-77-C-3073 with the United States Air Force Systems Command, Wright-Patterson Air Force Base, Ohio. The subject contract was initiated under Air Force Flight Dynamics Laboratory Project 8219, task 82190115 on 15 August 1977 and was effectively concluded in November 1978. This report supersedes AFFDL TR-73-23 produced under contract F33615-73-C-3058 which extended the program to include Datcom Sections 6 and 7 and a trim option; and AFFDL-TR-76-45 that incorporated revisions and user flexibility under contract F33615-75-C-3043. The recent activity generated a plot module, updated methods to incorporate the 1976 Datcom revisions, and provide additional user oriented features. These contracts, in total, reflect a systematic approach to Datcom automation which commenced in February 1972. Mr. J. E. Jenkins, AFFDL/FGC, was the Air Force Project Engineer for the previous three contracts and Mr. B. F. Niehaus acted in this capacity for the current contract. The authors wish to thank Mr. Niehaus for his assistance, particularly in the areas of computer program formulation, implementation, and verification.

Requests for copies of the computer program should be directed to the Air Force Flight Dynamics Laboratory (FGC). Copies of this report can be obtained from the National Technical Information Service (NTIS).

This report was submitted in April 1979.

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SECTION 1

INTRODUCTION

In preliminary design operations, rapid and economical evaluation of aerodynamic stability and control characteristics are usually essential. The USAF Stability and Control Digital Datcom provides estimates for these characteristics; however, graphical representation of data is normally required for an expedient evaluation of the vehicle aerodynamic characteristics.

This report describes the USAF Digital Datcom Plot Module. This module provides the user with a graphical representation of data calculated by Digital Datcom. The Plot Module was developed as a separate program, or post processor, to provide the user with maximum flexibility, simplicity, and economy. These benefits are realized because the module is not required to operate within the Digital Datcom logic and structure, but interfaces with a file written from the Digital Datcom Output Modules. A schematic of the Plot Module interfaces is presented in Figure 1.

The Digital Datcom Plot Module produces plots of the following Digital Datcom data:

1. static stability characteristics, including the longitudinal and lateral-directional stability derivatives;
2. wing downwash and dynamic pressure ratio data in the region of the horizontal tail, for configurations with a wing and horizontal tail;
3. high-lift and control characteristics generated from symmetrical and asymmetrical flap analysis; and
4. trim data for configurations with flap or all moveable horizontal tail controls.

The Digital Datcom Plot Module was designed to operate in a batch mode utilizing an "off line" plotter. An "off line" plotting system is one in which the program writes plot data and commands to an external file, usually a magnetic tape. This tape is then used to drive the plotter as illustrated in Figure 1. An "on line" version of the program may be generated by converting the CALCOMP software calls to the appropriate calls for the system in use. In an "on line" system, the plot data and commands are transmitted

directly to the plotter, usually a Cathode Ray Tube (CRT). The CALCOMP subroutines used by the plot module are discussed in the Appendix.

This program is written in the FORTRAN IV language for the CDC CYBER 74 and 175 computers. The deviations from ANSI standard FORTRAN were transfer on end of file and those statements required by the CDC compilers. The program utilizes the CALCOMP plotter software available at the AFFDL, ASD computer center.

Direct all program inquiries to AFFDL FGC, Wright-Patterson Air Force Base, Ohio, 45433. Phone (513) 255-4315.

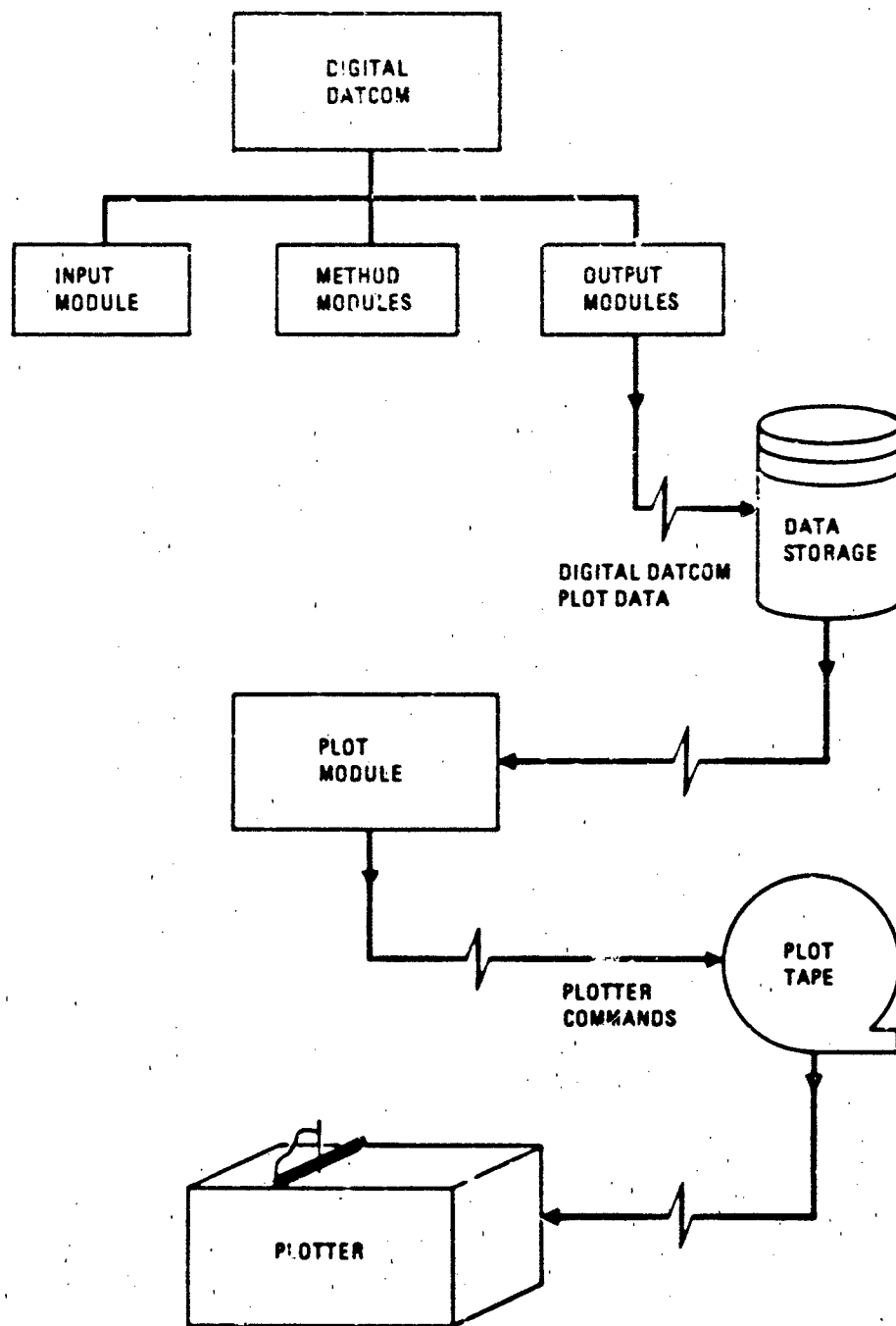


FIGURE 1 PLOT MODULE INTERFACES

SECTION 2

PROGRAM CAPABILITIES

The Digital Datcom plot module displays aerodynamic data calculated using Digital Datcom. Plots can be obtained of the static stability, high-lift and control, and trim data. The user is referred to Datcom and Volumes I and II of this report for a discussions of the available data.

2.1 PROGRAM DESCRIPTION

Digital Datcom computations consist of one or more cases, where each case consists of the aerodynamic analysis of a configuration over a range of flight conditions. Plot module output also consists of one or more cases, with each plot case producing plots of a single Digital Datcom case. The aerodynamic data plotted by this program are located on a file written by Digital Datcom. The structure of this file is discussed in Section 5. Data from sources other than Digital Datcom may be plotted by creating a file with the proper format.

The plot module can accept data from one or two aerodynamic data files in a single case and up to four different files during each program execution. This permits the user to generate plots showing comparisons between two Digital Datcom runs or between Digital Datcom output and test data. If two files are read simultaneously, they are assumed to have the same flight condition and reference data. The user has the option to select one of three basic codes for displaying each file. The three codes are: a solid line between data points, a solid line with symbols at the data points, and symbols at the data points and no line.

A Digital Datcom aerodynamic data file contains the static stability portion of the Ideal Output Matrix (IOM), see Appendix C of Volume I. Therefore, all of the configuration build-up data calculated by Digital Datcom are available to the plot module. The user has the option to generate configuration build-up plots and specify the component combinations that will be plotted.

2.2 PLOT GROUPS

The plot module can produce 47 different plots of Digital Datcom data. In order to more efficiently process these plots, they have been

divided into seven groups of related data. The types of plots within each group are defined below.

- o GROUP 1 - Static Stability as a Function of Angle of Attack.
- o GROUP 2 - Drag Polars and Stability Plots
- c GROUP 3 - Downwash Data
- o GROUP 4 - Mach Effects
- o GROUP 5 - Symmetrical Flap Data
- o GROUP 6 - Asymmetrical Flap Data
- o GROUP 7 - Trim Data

Data from plot groups 1 through 4 will be plotted unless the user specifies that the group is inactive. Within each of these four groups, the plots are initially defined as active or inactive; however, the user can override the preset values. Active plots are produced whenever the plot group is active. Plot groups 5 through 7 are nominally inactive and will be plotted only at the request of the user. The plots in these three groups are nominally inactive and must be specifically requested by the user. A description of the individual plots in each group and their default activity status is given in Section 3.8.

2.3 PLOT FORMAT

The basic plot format is shown in Figure 2. The first two lines in the label at the top of the plot are user defined. The next three lines defining the flight condition and reference data are fixed. On Mach number plots (Group 4), the Mach number and Reynolds number information is not drawn and the altitude is given instead. The axis labels are defined in the program, however, the user has the option to change them. Axis scaling is determined internally by the program, with a user option available to override the internal scaling and define scale limits. The configuration build-up combinations shown in Figure 2, demonstrate the labeling technique used when multiple lines appear on a plot. Configuration build-up combinations plotted are also a user option.

DIGITAL DATCOM

SAMPLE PLOT

MACH NO. = .60 REYNOLDS NO. = 3.50×10^6
 SREF = 2.250 FT CBAR = .822 FT SPAN = 3.000 FT
 XCG = 2.60 FT ZCG = .00 FT

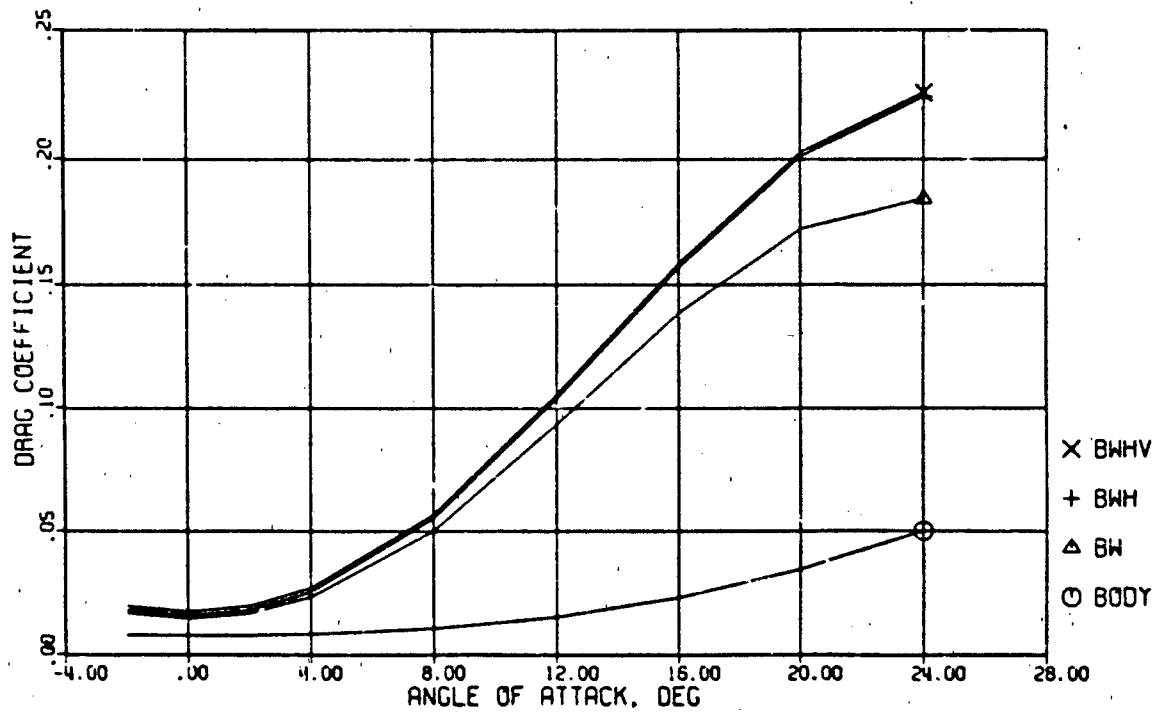


FIGURE 2 SAMPLE PLOT

SECTION 3

INPUT DATA DEFINITION

There are two sets of input data required by the Plot Module; Digital Datcom plot data, and plot module control data. The Digital Datcom plot data are located on a file generated by Digital Datcom when the "PLOT" control card is present in a case (see Volume I, Section 3.5). A maximum of four of these files may be used during any single execution of the plot module and are read from I/O units 11 through 14. The plot module control data define which plots will be generated and their format. These control cards are read from the normal input stream.

There are 15 control cards recognized by the plot module. These cards, like the Digital Datcom control cards, have the following characteristics.

1. Each card consists of a control word, starting in column 1, that defines the program function under control.
2. Control cards may appear in any order in the input stream, with the exception of the case termination cards. However, there are some limitations with regard to the PLOT, SCALE, and LABEL cards.
3. The control cards may appear more than one time within a case, the last appearance will be used.
4. If a given control card is not input, the program defaults are used. Each control card and the corresponding program defaults are defined in the following subsections.

The plot module control cards also contain input data following the control word. These data are formatted inputs, and must be located in the correct columns in order to be properly read. Five additional rules for the plot module control card inputs are given below.

1. Input data for an integer variable does not have a decimal point and is right justified in the card column field. Integer variables start with the letters I through N.
2. Input data for real variables must have a decimal point and may be located anywhere in the card column field. Real variables start with the letters A through H and Ø through Z.
3. When a control card is used, all of the required input data must be defined.

4. All input variables are initialized prior to reading case data and are not saved for the following case unless requested by the user.
5. The control word on each card must be followed by at least one blank.

The plot control cards are summarized in Figure 3 and discussed in detail below. It is suggested that the user study the example problem in Section 4.

All input variables and common arrays are initialized "UNUSED" (1.0 E-60 on CDC systems) prior to case execution. The program uses the value of "UNUSED" as a program switch to determine if particular real variables have been defined. In the Plot Module, these tests are performed on the user defined scale limits (see SCALE Card), and on data in the Digital Datcom plot file.

To aid the user in interpreting the input data definitions, the character "0" is the number zero and the character "Ø" is the fifteenth letter in the alphabet.

3.1 FILE CARD

The FILE card specifies the files containing Digital Datcom plot data and defines the case that will be plotted. Two separate files may be defined for each plot case thereby providing plotted comparisons between two sets of data. These two files are designated the "A" and "B" files. File A is the primary file and is used to read the flight condition and reference data and set the plot scales. Care must be exercised when two files are being plotted, the scale limits are defined using file A and if some data from file B falls outside these limits it will not be plotted. File "A" must be defined for every plot case, file "B" is optional. The program default defines file "A" on I/Ø unit 11 and file "B" as not present. File "B" is assumed to be absent whenever the I/Ø unit number is outside the range of 11 to 14. The user may therefore "turn off" file "B" by setting the unit number to zero. The format of the FILE card and definition of its input data are given below.

| <u>Column</u> | <u>Code</u> | <u>Explanation</u> |
|---------------|-------------|--|
| 2-4 | FILE | Control word. The four letters FILE. |
| 7 | ID | File identification. Input either the letter A or B. |

| <u>Column</u> | <u>Code</u> | <u>Explanation</u> |
|---------------|-------------|--|
| 8-10 | IUNIT | File I/Ø unit number, right justified integer in the range 11 to 14 ($11 \leq IUNIT \leq 14$). If the unit number is outside this range for file B, it is not read or plotted. Defaults: File A, IUNIT = 11; File B, IUNIT = 0. |
| 11-13 | ICASE | Digital DATCOM case number to be plotted, right justified integer ($ICASE \geq 1$). Defaults: File A, ICASE = 1; File B, ICASE = 1. |

3.2 LINE CARD

The LINE card controls the method of drawing lines between Digital Datcom data points and the drawing of symbols around the data points. The plot module provides three options for drawing lines between points; straight line between points, a splined curve between points, and no line drawn. The user also has the option to have symbols drawn around the data points in conjunction with any of the three line codes. Separate line code options may be assigned to files A and B. The format of the LINE card and definition of its input data are given below.

| <u>Column</u> | <u>Code</u> | <u>Explanation</u> |
|---------------|-------------|---|
| 1-4 | LINE | Control word. The four letters LINE. |
| 7 | ID | File identification. Input either the letter A or B. |
| 8-10 | ILINE | Line code for the designated file, right justified integer. The three codes are: ILINE = 0, straight line between points ILINE \geq 1, spline curve ILINE \leq -1, no line drawn. Defaults: File A, ILINE = 0 File B, ILINE = 0 |

| <u>Column</u> | <u>Code</u> | <u>Explanation</u> |
|------------------|-------------|---|
| 11-13 | ISYM | Symbol code for the designated file, right justified integer. The codes are: ISYM = 0, no symbols are drawn ISYM = j, ($j \geq 1$), symbols are drawn at every jth point. |
| Defaults: | | |
| File A, ISYM = 0 | | |
| File B, ISYM = 0 | | |

3.3 TITLE CARDS

Two control cards are used to specify the user defined titles that are drawn at the top of the plot (see Figure 2). The control card TITLE1 specifies the title drawn on the top line, and the control card TITLE2 specifies the title drawn on the second line. The user specifying only one title line may prefer to use only the TITLE2 control card. The format of the TITLE cards and definition of their input data are given below.

| <u>Column</u> | <u>Code</u> | <u>Explanation</u> |
|---------------|------------------------|--|
| 1-6 | TITLE1 or TITLE2 | Control word. The five letters and number TITLE1 or TITLE2. |
| 8-9 | NC | The number of characters in the title, right justified integer ($0 \leq NC \leq 40$). If $NC = 0$, the title is not drawn. The maximum number of characters is 40, counting inbedded blanks. Default: TITLE1, NC = 0; TITLE2, NC = 0. |
| 11-50 | title | Text of the title. The characters must be left justified in the field. |

3.4 BUILD CARD

The BUILD card permits the user to select the configuration components and component combinations that will be drawn on each plot. The control word, BUILD, must be followed by at least one blank and the configuration codes. There are four basic forms for the configuration codes. Regardless of the form specified, data for the complete configuration will always be

plotted. The format of the BUILD card and definition of the four forms for the configuration codes are given below.

| <u>Column</u> | <u>Code</u> | <u>Explanation</u> |
|---------------|-------------|--|
| 1-5 | BUILD | Control word. The five letters BUILD. |
| 7-80 | Code | 1. One or more of the IOM configuration codes defined below. Each code must be separated by a blank or a comma. |
| | ALL | 2. All, the three letters ALL. All of the components and component combinations defined in the Digital DATCOM run will be plotted. |
| | NONE | 3. None, the four letters NONE. Only data for the complete configuration will be plotted. |
| | blank | 4. No codes given columns 7 to 80 are blank. The IOM configuration codes B, BW, BWH, and BWHV are selected. Configuration data not calculated in Digital DATCOM will not be plotted. |

Default:

Code = NONE.

The Ideal Output Matrix (IOM) consists of eleven configuration components and component combinations that may be plotted. Each IOM configuration is assigned a one to four character code that is used on the first form of the BUILD card. These codes are defined below.

| <u>IOM Config. Code</u> | <u>Definition</u> |
|-------------------------|--|
| B | Body alone |
| W | Wing alone |
| H | Horizontal tail alone |
| VT | Vertical tail alone |
| VF | Ventral fin alone |
| BW | Body plus Wing |
| BH | Body plus Horizontal tail |
| BV | Body, Vertical tail and/or Ventral fin |

| | |
|------|---|
| BWH | Body, Wing, Horizontal tail |
| BWV | Body, Wing, Vertical tail and/or Ventral fin |
| BWHV | Body, Wing, Horizontal tail, Vertical tail and/or Ventral fin |

3.5 MACH CARD

The MACH card gives the user the option to specify the Mach numbers selected for plots at constant Mach number. Plots with Mach number as the independent variable are not affected by this card. The Mach numbers to be plotted are selected by specifying the Mach number index in the Digital Datcom Mach list. The Mach list is defined in Volume I of this report under Namelist FLTC0N. If the MACH card is not input, plots will be generated at all the Mach numbers in the Digital Datcom output. The format of the MACH card and definition of its input data are given below

| <u>Column</u> | <u>Code</u> | <u>Explanation</u> |
|---------------|-------------|--------------------------------------|
| 1-4 | MACH | Control word, the four letters MACH. |
| 6-8 | IM(1) | |
| 9-11 | IM(2) | |
| 12-14 | IM(3) | |
| 15-17 | IM(4) | |
| 18-20 | IM(5) | |
| 21-23 | IM(6) | Index to Mach number in Mach list, |
| 24-26 | IM(7) | right justified integers. Indices |
| 27-29 | IM(8) | may be in any order. For example, |
| 30-32 | IM(9) | to specify the first and third Mach |
| 33-35 | IM(10) | numbers the Mach card may be coded |
| 36-38 | IM(11) | in any of the following ways: |
| 39-41 | IM(12) | MACH 1 3, |
| 42-44 | IM(13) | MACH 3 1, |
| 54-47 | IM(14) | etc. |
| 48-50 | IM(15) | |
| 51-53 | IM(16) | |
| 54-56 | IM(17) | |
| 57-59 | IM(18) | |
| 60-62 | IM(19) | |
| 63-65 | IM(20) | |

3.6 ALT CARD

The ALT card gives the user the option to specify the altitudes at which Digital Datcom data will be plotted. This card is utilized with data that were computed with altitude looping options 2 or 3. These options are defined in Volume I (namelist FLTCØN, variable name LØØP). The altitudes to be plotted are selected by specifying the altitude index in the Digital Datcom altitude list (see Volume I, namelist FLTCØN, variable ALT). The format of the ALT card and definition of its input data are given below.

| <u>Column</u> | <u>Code</u> | <u>Explanation</u> |
|---------------|-------------|---|
| 1-3 | ALT | Control word, the three letters ALT. |
| 6-8 | IA(1) | |
| 9-11 | IA(2) | |
| 12-14 | IA(3) | |
| 15-17 | IA(4) | |
| 18-20 | IA(5) | |
| 21-23 | IA(6) | |
| 24-26 | IA(7) | |
| 27-29 | IA(8) | |
| 30-32 | IA(9) | Index to altitude in altitude list, right |
| 33-35 | IA(10) | justified integers. Indices may be in |
| 36-38 | IA(11) | any order. See the example given with |
| 39-41 | IA(12) | the MACH card. |
| 42-44 | IA(13) | |
| 45-47 | IA(14) | |
| 48-50 | IA(15) | |
| 51-53 | IA(16) | |
| 54-56 | IA(17) | |
| 57-59 | IA(18) | |
| 60-62 | IA(19) | |
| 63-65 | IA(20) | |

3.7 GROUP CARD

The plots produced by this module are divided into seven distinct plot groups as described in Section 2.2. Each group contains related data; such as static stability plots, downwash plots, etc. The specific plots in each plot group are shown in Figures 4 through 10. Plot groups one through four

are plotted by default and groups five through seven at the users option. The GRØUP card performs two functions: (1) it activates, or deactivates, a plot group; and (2) defines the group number for subsequent definition of the plots that will be created and (optionally) their scaling and axis labels. Thus, even if the group is nominally active the group card must be used if these options are exercised. The format of the GRØUP card and definition of its input data are given below.

| <u>Column</u> | <u>Code</u> | <u>Explanation</u> |
|---------------|-------------|---|
| 1-5 | GRØUP | Control word, the five letters GRØUP. |
| 7-8 | NGP | Plot group number, right justified integer. |
| | | NGP = group number |
| | | If $NGP \leq -1$, the group is deactivated |
| | | If $NGP \geq 1$, the group is active and the |
| | | PLØT, SCALE, and LABEL |
| | | control cards can refer to |
| | | the group. |

Default: Groups 1, 2, 3, and 4 are active,
groups 5, 6, and 7 are inactive.

Note: Plots are produced only from active
plot groups.

3.8 PLØT CARD

The PLØT card must follow a GRØUP card that defines an active plot group (i.e. $1 \leq NGP \leq 7$). Other control cards may be placed between the GRØUP and PLØT cards; however, each PLØT card refers to the immediately preceding GRØUP card. A PLØT card performs two functions: (1) it activates, or deactivates, a plot; and (2) defines a plot for subsequent optional definition of its scales and axis labels. A PLØT card must be supplied for each plot for which SCALE or LABEL control cards are used. A definition of the nominally active and inactive plots are given in Figures 4 through 10. For a plot to be drawn, it must be in an active plot group. The format of the PLØT card and definition of its input data are given below.

| <u>Column</u> | <u>Code</u> | <u>Explanation</u> |
|---------------|-------------|--------------------------------------|
| 1-4 | PLØT | Control word, the four letters PLØT. |
| 6-8 | NPLT | Plot number, right justified integer |
| | | NPLT = plot number in group NGP (see |
| | | GROUP card). |

If $NPLT < -1$, the plot is deactivated
If $NPLT > 1$, the plot is active and the
SCALE and LABEL control
cards can refer to it.

Default: see Figures 4 to 10

3.9 SCALE CARD

The SCALE card allows the user to specify the upper and lower limits of the plot scales. These limits may be adjusted so that the increment between annotations on the axis is 1, 2, 4, 5, or 8 times a power of ten (see Section 6.9). Any data that lies outside of the final upper and lower scale limits will not be plotted. If the axis scales are not specified, or set equal to "UNUSED," the program automatically defines the plot scales. The SCALE card must follow a PLOT card that defines an active plot. Other control cards may be placed between the PLOT and SCALE cards, however, the SCALE card refers to the immediately preceding PLOT card. The format of the SCALE card and definition of its input data are given below.

| <u>Column</u> | <u>Code</u> | <u>Explanation</u> |
|---------------|-------------|---|
| 1-5 | SCALE | Control word, the five letters SCALE. |
| 7 | AXIS | Axis identification, either the letter X or Y. |
| 11-20 | SL | Scale lower limit, real number. |
| 21-30 | SU | Scale upper limit, real number. |

3.10 LABEL CARD

The LABEL card allows the user to specify the label that will appear along the axes of each plot. The default axis labels for each plot are given in Figures 4 through 10. The LABEL card must follow a PLOT card that defines an active plot. Other control cards may be placed between the PLOT and LABEL cards, however, the LABEL card refers to the immediately preceding PLOT card. The format of the LABEL card and its input data are defined below.

| <u>Column</u> | <u>Code</u> | <u>Explanation</u> |
|---------------|-------------|---|
| 1-5 | LABEL | Control word, the five letters LABEL |
| 7 | AXIS | Axis identification. Input either the letter X or Y. |

| <u>Column</u> | <u>Code</u> | <u>Explanation</u> |
|---------------|-------------|--|
| 9-10 | NC | The number of characters in the axis label, right justified integer. If NC = 0, a label is not drawn. |
| 11-50 | Title | Text of the label. The characters must be left justified in the field. Default: see Figures 4 through 11. |

3.11 GRID CARD

The GRID card controls the drawing of a one inch grid on the plot field. The format of the GRID card and its input data are given below.

| <u>Column</u> | <u>Code</u> | <u>Explanation</u> |
|---------------|-------------|--|
| 1-4 | GRID | Control word, the four letters GRID. |
| 6-8 | IG | Grid code, right justified integer. If $IG \leq -1$ no grid is drawn. If $IG \geq 0$ a one inch grid is drawn. Default: IG = -1. |

3.12 SAVE CARD

When the SAVE card is present in a case, all of the control cards input for that case are preserved for use in the following case. The use of this card minimizes the inputs required for multiple case jobs. The total number of control cards in consecutive save cases cannot exceed 100, this includes multiple occurrences of the same control card. The format of the SAVE card is given below.

| <u>Column</u> | <u>Code</u> | <u>Explanation</u> |
|---------------|-------------|--------------------------------------|
| 1-4 | SAVE | Control word, the four letters SAVE. |

3.13 NEXT CASE CARD

This control card terminates the input data for a case and initiates plotting. Any control cards following this card are in the following case. After the case plotting is complete, the program will return to the input routine and expect inputs for another case. The format of the NEXT CASE card is given below.

| <u>Column</u> | <u>Code</u> | <u>Explanation</u> |
|---------------|-------------|--|
| 1-9 | NEXT CASE | Control word, the two word NEXT and CASE separated by a blank. |

3.14 END CARD

The END card performs the same functions as the NEXT CASE card; however, after the case plotting is complete, the program execution is terminated. An end-of-file on the input stream has the same effect as the END card. The format of the END card is given below.

| <u>Column</u> | <u>Code</u> | <u>Explanation</u> |
|---------------|-------------|--------------------------------------|
| 1-3 | END | Control word, the three letters END. |

Blank

- ID - FILE IDENTIFICATION (A OR B)
- IUNIT - FILE UNIT NUMBER (11 to 14 FOR ACTIVE FILES), INTEGER
- ICASE - CASE NUMBER ON FILE, INTEGER
- ILINE - LINE CODE, INTEGER
 = -1, NO LINE
 = 0, STRAIGHT LINE, DEFAULT
 = 1, SPLINE CURVE
- ISYM - SYMBOL CODE, INTEGER
 = 0, NO SYMBOLS, DEFAULT
 = j, SYMBOL ON EVERY jth point.
- NC - NUMBER OF CHARACTERS IN TITLE, INTEGER
- IM - MACH NUMBER INDICES, INTEGER
- IA - ALTITUDE INDICES, INTEGER
- AXIS - AXIS IDENTIFICATION (X OR Y)
- SL - SCALE LOWER LIMIT, REAL
- SU - SCALE UPPER LIMIT, REAL
- IG - GRID CODE, INTEGER
 ≤ -1 NO GRID ON PLOT, DEFAULT
 ≥ 0 GRID WILL BE DRAWN ON PLOT

| 1-10 | | | | | | | | | | 11-20 | | | | | | | | | | | | | |
|-----------|---|---|---|---|---|---|---|---|----|-------|----|-------|----|-------|----|----|----|----|----|---|--|--|--|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | | | | |
| | | | | | | | | | | ID | | IUNIT | | ICASE | | | | | | | | | |
| FILE | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | ID | | ILINE | | ISYM | | | | | | | | | |
| LINE | | | | | | | | | | | | | | | | | | | | | | | |
| NC | | | | | | | | | | | | | | | | | | | | | | | |
| TITLE1 | | | | | | | | | | | | | | | | | | | | | | | |
| TITLE2 | | | | | | | | | | | | | | | | | | | | | | | |
| BUILD | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | i=1 | | 2 | | 3 | | 4 | | 5 | | 6 | | | |
| MACH | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | i=1 | | 2 | | 3 | | 4 | | 5 | | 6 | | | |
| ALT | | | | | | | | | | | | | | | | | | | | | | | |
| NGP | | | | | | | | | | | | | | | | | | | | | | | |
| GROUP | | | | | | | | | | | | | | | | | | | | | | | |
| NPLT | | | | | | | | | | | | | | | | | | | | | | | |
| PLOT | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | AXIS | | | | | SL | | | | | | | | |
| SCALE | | | | | | | | | | | | | | | | | | | | | | | |
| AXIS NC | | | | | | | | | | | | | | | | | | | | | | | |
| LABEL | | | | | | | | | | | | | | | | | | | | | | | |
| IG | | | | | | | | | | | | | | | | | | | | | | | |
| GRID | | | | | | | | | | | | | | | | | | | | | | | |
| SAVE | | | | | | | | | | | | | | | | | | | | | | | |
| NEXT CASE | | | | | | | | | | | | | | | | | | | | | | | |
| END | | | | | | | | | | | | | | | | | | | | | | | |

FIGURE 3 PLOT MODULE CONTROL CARD SUMMARY

| 21-30 | | | | | | | | | | 31-40 | | | | | | | | | | 41-50 | | | | | | | | | | 51-60 | | | | | | | | | | 61-70 | | | | | | | | | | 71-80 | | | | | | | | | |
|-------|---|---|---|---|---|---|---|---|---|-------|---|---|---|---|---|---|---|---|---|-------|---|---|---|---|---|---|---|---|---|-------|---|---|---|---|---|---|---|---|---|-------|---|---|---|---|---|---|---|---|---|-------|---|---|---|---|---|---|---|---|---|
| 4 | 5 | 6 | 7 | 8 | 9 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 0 | 1 | 2 | 3 |

TITLE TEXT

CONFIGURATION CODES

MACH NUMBER INDICIES (M_i)

| 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|---|---|----|----|----|----|----|----|----|----|----|----|----|
| | | | | | | | | | | | | | |

ALTITUDE INDICIES (A_i)

| 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|---|---|----|----|----|----|----|----|----|----|----|----|----|
| | | | | | | | | | | | | | |

SU

TITLE TEXT

NOTES: Leave Unused Columns Blank

Integer variables are right justified in the input field.

Titles are left justified in the input field.

Real variables must have a decimal point.

2

PLOT GROUP 1
STATIC STABILITY DATA

| NO. | TYPE* | DESCRIPTION | AXIS | AXIS LABEL |
|-----|-------|----------------------------|------|------------------------------------|
| 1 | A | C_D VS. α | Y | DRAG COEFFICIENT |
| | | | X | ANGLE OF ATTACK, DEG |
| 2 | A | C_L VS. α | Y | LIFT COEFFICIENT |
| | | | X | ANGLE OF ATTACK, DEG |
| 3 | A | C_m VS. α | Y | PITCHING MOMENT COEFFICIENT |
| | | | X | ANGLE OF ATTACK, DEG |
| 4 | I | C_N VS. α | Y | NORMAL FORCE COEFFICIENT |
| | | | X | ANGLE OF ATTACK, DEG |
| 5 | I | C_A VS. α | Y | AXIAL FORCE COEFFICIENT |
| | | | X | ANGLE OF ATTACK, DEG |
| 6 | I | $C_{L\alpha}$ VS. α | Y | LIFT CURVE SLOPE, 1/DEG |
| | | | X | ANGLE OF ATTACK, DEG |
| 7 | I | $C_{m\alpha}$ VS. α | Y | PITCHING MOMENT COEF. SLOPE, 1/DEG |
| | | | X | ANGLE OF ATTACK, DEG |
| 8 | I | $C_{Y\beta}$ VS. α | Y | SIDE FORCE COEF. DERIV., 1/DEG |
| | | | X | ANGLE OF ATTACK, DEG |
| 9 | I | $C_{n\beta}$ VS. α | Y | YAWING MOMENT COEF. DERIV., 1/DEG |
| | | | X | ANGLE OF ATTACK, DEG |
| 10 | I | $C_{l\beta}$ VS. α | Y | ROLLING MOMENT COEF. DERIV., 1/DEG |
| | | | X | ANGLE OF ATTACK, DEG |

*NOMINAL PLOTTING TYPE
A - ACTIVE PLOT
I - INACTIVE PLOT

FIGURE 4 · GROUP 1 PLOTS

PLOT GROUP 2
DRAG POLARS AND STABILITY PLOTS

| NO. | TYPE* | DESCRIPTION | AXIS | AXIS LABEL |
|-----|-------|-----------------|------|-----------------------------|
| 1 | A | C_L VS. C_m | Y | LIFT COEFFICIENT |
| | | | X | PITCHING MOMENT COEFFICIENT |
| 2 | A | C_L VS. C_D | Y | LIFT COEFFICIENT |
| | | | X | DRAG COEFFICIENT |
| 3 | I | C_N VS. C_A | Y | NORMAL FORCE COEFFICIENT |
| | | | X | AXIAL FORCE COEFFICIENT |
| 4 | I | C_N VS. C_m | Y | NORMAL FORCE COEFFICIENT |
| | | | X | PITCHING MOMENT COEFFICIENT |

*NOMINAL PLOTTING TYPE
A - ACTIVE PLOT
I - INACTIVE PLOT

FIGURE 5 GROUP 2 PLOTS

**PLOT GROUP 3
DOWNWASH DATA**

| NO. | TYPE* | DESCRIPTION | AXIS | AXIS LABEL |
|-----|-------|--|------|----------------------------------|
| 1 | A | q/q_{∞} VS. α | Y | DYNAMIC PRESSURE RATIO |
| | | | X | ANGLE OF ATTACK, DEG |
| 2 | A | ϵ VS. α | Y | DOWNWASH ANGLE, DEG |
| | | | X | ANGLE OF ATTACK, DEG |
| 3 | A | $\frac{d\epsilon}{d\alpha}$ VS. α | Y | DOWNWASH GRADIENT |
| | | | X | ANGLE OF ATTACK, DEG |
| 4 | I | $(\epsilon)_g$ VS. α | Y | CARNARD EFF. DOWNWASH ANGLE, DEG |
| | | | X | ANGLE OF ATTACK, DEG |
| 5 | I | $(d\epsilon/d\alpha)_g$ VS. α | Y | CARNARD EFF. DOWNWASH GRADIENT |
| | | | X | ANGLE OF ATTACK, DEG |

*NOMINAL PLOTTING TYPE
A - ACTIVE PLOT
I - INACTIVE PLOT

FIGURE 6 GROUP 3 PLOTS

PLOT GROUP 4
MACH EFFECTS

| NO. | TYPE* | DESCRIPTION | AXIS | AXIS LABEL |
|-----|-------|----------------------|------|------------------------------------|
| 1 | A | C_{D_0} VS. M | Y | ZERO LIFT DRAG COEFFICIENT |
| | | | X | MACH NUMBER |
| 2 | A | C_{L_α} VS. M | Y | LIFT CURVE SLOPE, 1/DEG |
| | | | X | MACH NUMBER |
| 3 | A | C_{m_α} VS. M | Y | PITCHING MOMENT COEF. SLOPE, 1/DEG |
| | | | X | MACH NUMBER |
| 4 | I | C_{Y_β} VS. M | Y | SIDE FORCE COEF. DERIV., 1/DEG |
| | | | X | MACH NUMBER |
| 5 | I | C_{n_β} VS. M | Y | YAWING MOMENT COEF. DERIV., 1/DEG |
| | | | X | MACH NUMBER |
| 6 | I | C_{l_β} VS. M | Y | ROLLING MOMENT COEF. DERIV., 1/DEG |
| | | | X | MACH NUMBER |

*NOMINAL PLOTTING TYPE
A - ACTIVE PLOT
I - INACTIVE PLOT

FIGURE 7 GROUP 4 PLOTS

**PLOT GROUP 5
SYMETRICAL FLAP DATA**

| NO. | TYPE* | DESCRIPTION | AXIS | AXIS LABEL |
|-----|-------|--|------|-------------------------------------|
| 1 | I | ΔC_L VS. δ | Y | LIFT COEFFICIENT INCREMENT |
| | | | X | FLAP DEFLECTION, DEG |
| 2 | I | ΔC_m VS. δ | Y | PITCHING MOMENT COEF. INCREMENT |
| | | | X | FLAP DEFLECTION, DEG |
| 3 | I | $\Delta C_{L_{max}}$ VS. δ | Y | MAX. LIFT COEF. INCREMENT |
| | | | X | FLAP DEFLECTION, DEG |
| 4 | I | $\Delta C_{D_{min}}$ VS. δ | Y | MIN. DRAG COEF. INCREMENT |
| | | | X | FLAP DEFLECTION, DEG |
| 5 | I | $(C_{L_{\alpha}})_{\delta}$ VS. δ | Y | (CLAD) - DERIV. OF LIFT COEF. SLOPE |
| | | | X | FLAP DEFLECTION, DEG |
| 6 | I | $C_{h_{\alpha}}$ VS. δ | Y | CHA - HINGE MOMENT DERIV., 1/DEG |
| | | | X | FLAP DEFLECTION, DEG |
| 7 | I | $C_{h_{\delta}}$ VS. δ | Y | CHD - HINGE MOMENT DERIV., 1/DEG |
| | | | X | FLAP DEFLECTION, DEG |
| 8 | I | ΔC_{D_i} VS. α , AT CONST. δ | Y | INDUCED DRAG INCREMENT |
| | | | X | ANGLE OF ATTACK, DEG |

*NOMINAL PLOTTING TYPE

A - ACTIVE PLOT
I - INACTIVE PLOT

FIGURE 8 GROUP 5 PLOTS

**PLOT GROUP 6
ASYMMETRICAL FLAP DATA**

| NO. | TYPE* | DESCRIPTION | AXIS | AXIS LABEL |
|-----|-------|--|------|-----------------------------------|
| 1 | I | C_l VS. δ/c | Y | ROLLING MOMENT COEFFICIENT |
| | | | X | SPOILER HEIGHT, FRACTION OF CHORD |
| 2 | I | C_n VS. δ/c | Y | YAWING MOMENT COEFFICIENT |
| | | | X | SPOILER HEIGHT, FRACTION OF CHORD |
| 3 | I | C_n VS. α , AT CONST. $(\delta_L - \delta_R)$ | Y | YAWING MOMENT COEFFICIENT |
| | | | X | ANGLE OF ATTACK, DEG |
| 4 | I | C_l VS. $(\delta_L - \delta_R)$ | Y | ROLLING MOMENT COEFFICIENT |
| | | | X | INCREMENTAL FLAP DEFL. (L-R), DEG |
| 5 | I | C_l VS. α , AT CONST. $(\delta_L - \delta_R)$ | Y | ROLLING MOMENT COEFFICIENT |
| | | | X | ANGLE OF ATTACK, DEG |

*NOMINAL PLOT TYPE

A - ACTIVE PLOT

I - INACTIVE PLOT

FIGURE 9 GROUP 6 PLOTS

PLOT GROUP 7

TRIM DATA

| NO. | TYPE* | DESCRIPTION | | AXIS | AXIS LABEL |
|-----|-------|-----------------------------------|---|------|----------------------------------|
| 1 | I | δ_t VS. α | TRIM WITH FLAPS | Y | TRIM FLAP DEFLECTION, DEG |
| | | | | X | ANGLE OF ATTACK, DEG |
| 2 | I | ΔC_L VS. α | | Y | LIFT COEFFICIENT INCREMENT |
| | | | | X | ANGLE OF ATTACK, DEG |
| 3 | I | $\Delta C_{L_{max}}$ VS. α | | Y | MAX. LIFT COEF. INCREMENT |
| | | | | X | ANGLE OF ATTACK, DEG |
| 4 | I | ΔC_{D_i} VS. α | | Y | INDUCED DRAG INCREMENT |
| | | | | X | ANGLE OF ATTACK, DEG |
| 5 | I | $\Delta C_{D_{min}}$ VS. α | | Y | MIN. DRAG COEF. INCREMENT |
| | | | | X | ANGLE OF ATTACK, DEG |
| 6 | I | $C_{h\delta}$ VS. α | | Y | CHD - HINGE MOMENT DERIV., 1/DEG |
| | | | | X | ANGLE OF ATTACK, DEG |
| 7 | I | α_{it} VS. α | ALL MOVEABLE HORIZONTAL TAIL TRIM | Y | TRIM HORIZ. TAIL INCIDENCE, DEG |
| | | | | X | ANGLE OF ATTACK, DEG |
| 8 | I | C_L VS. α | | Y | LIFT COEFFICIENT |
| | | | | X | ANGLE OF ATTACK, DEG |
| 9 | I | C_D VS. α | | Y | DRAG COEFFICIENT |
| | | | | X | ANGLE OF ATTACK, DEG |

*NOMINAL PLOT TYPE
A - ACTIVE PLOT
I - INACTIVE PLOT

FIGURE 10 GROUP 7 PLOT

SECTION 4

SAMPLE CASES

The example problem discussed in this section was designed to illustrate the plot module features and to use of all the available control cards. Two sets of Digital Datcom plot data are utilized and the input data for both Digital Datcom problems are shown in Figure 11. Problem one uses the configuration of example problem 3 in Volume I and is run at six subsonic Mach numbers. Case one is the basic configuration data and case two adds a symmetrical flap on the horizontal tail. Problem two uses the configuration from problem one with the wing span reduced by 16 percent. Case one is the basic configuration data and case two adds trim with an all moveable horizontal tail. These problems were designed to provide two data files with two cases on each file. The plot module accesses problem 1 on unit 11 and problem 2 on unit 12.

The plot module sample problem consists of six cases. These cases were designed to illustrate the use of all the plot module control cards and the various program features. The input data are shown in Figure 12 and a description of each case is given below.

4.1 PLOT CASE 1

This case presents the basic stability data for Digital Datcom problem one. It shows the plots that are generated by default, from two of the BUILD card, and the MACH card. The program will select Digital Datcom case one on I/O unit 11 by default, this is problem one case one. This case has six Mach numbers, therefore the MACH card is used to select just one Mach number when plotting data from plot groups, 1, 2, and 3. All six of the Mach numbers are used when plotting the Mach effects, plot group 4. The 11 plots for this case are shown in Figure 13.

4.2 PLOT CASE 2

This case presents a comparison of data from Digital Datcom problems one and two. Problem one is assigned to file A, I/O unit 11, and problem two to file B, I/O unit 12. This case demonstrates two line codes, the deactivation of plot groups, from one of the BUILD card, and use of the SAVE card. The MACH and TITLE cards are repeated for this case because they were not saved in case one. Only the three nominal plots from plot group one are produced for this case and are presented in Figure 14.

4.3 PLOT CASE 3

This case presents a drag comparison at low angles of attack. The input data from case two were saved, so only the additional inputs to select the drag coefficient plot and to scale the data are required. A grid is specified and the label of abscissa (Y-axis) is modified. The plot for this case is presented in Figure 15.

4.4 PLOT CASE 4

This case presents a complete configuration build-up of the zero lift drag as a function of Mach number. The input data from case three were saved, which includes the case two data. Plot one of group four is the only active plot and use of form four of the BUILD card is demonstrated. The plot for this case is presented in Figure 16.

4.5 PLOT CASE 5

This case presents the basic stability (group 1) and all moveable horizontal tail trim data found in Digital Datcom problem two, case two. The input data from case four was saved so file B must be deactivated and file A defined on I/O unit 12, case two. Plot group seven is activated and plots 7,8, and 9 are activated since all plots in this group are nominally inactive. Plot group one is reactivated and plots two and three are also reactivated. In case three, the scale limits and abscissa label were defined for plot one of group one. In this case the axis label is restored to its default value and automatic scaling is restored by inserting the program value for "UNUSED" on the scale cards. The plot grid is removed, form three of the BUILD card, and a spline curve through the data points are demonstrated. The six plots for this case are presented in Figure 17.

4.6 PLOT CASE 6

This case presents the incremental effects on lift, drag and pitching moment due to a plain trailing edge flap, Digital Datcom problem one, case two. A complete set of input data are required because a SAVE card did not appear in case five. Plots 1 and 2 in group five are active in this case, symbols are placed on every second data point, and a grid is drawn on the plots. Most computers interpret a blank input field as a zero, therefore the zero on the GRID card is not required. The two plots for this case are presented in Figure 18.

```

$PLITCON NALPHA=9.0,ALSCHD=-2.0,0.0,2.0,4.0,8.0,
12.0,16.0,20.0,24.0$
$FLTCO NMAC=6.0,MACH(1)=0.1,0.2,0.3,0.4,0.5,0.6,RNNUB(1)=6*4.26E6,$
$OPTINS SREF=2.25,CBARR=0.822,BLREF=3.00$
$SYNTHS XCG=2.60,ZCG=0.0,XW=1.70,ZW=0.0,ALIW=0.0,XH=3.93,ZH=0.0,
ALIH=0.0,XV=3.34,VERTUP=.TRUE., $
$BODY NX=10.0,BNOSE=2.0,BTAIL=1.0,BLN=1.46,BLA=1.97,
X(1)=0.0,.175,.322,.530,.85,1.46,2.50,3.43,3.97,4.57,
R(1)=0.0,.0417,.0833,.125,.1665,.208,.208,.208,.178,.138$
$WGPLNF CHRDTP=0.346,SSPNE=1.29,SSPN=1.50,CHDR=1.16,SAVSI=45.0,CHSTAT=.25,
SWAPP=0.0,TWISTA=0.0,SSPND=0.0,DHDADI=0.0,DHDADO=0.0,TYPE=1.0$
$WGSCHR TOVC=.060,DELTAY=1.30,XOVC=0.40,CLI=0.0,ALPHAI=0.0,CLALPA(1)=6*.131,
CLMAX(1)=6*.82,CMO=0.0,LERI=0.0025,CLAMO=.105$
$HTPLNF CHRDTP=.253,SSPNE=.52,SSPN=.67,CHDR=.42,SAVSI=45.0,CHSTAT=0.25,
SWAPP=0.0,TWISTA=0.0,SSPND=0.0,DHDADI=0.0,DHDADO=0.0,TYPE=1.0$
$HTSCHR TOVC=.060,DELTAY=1.30,XOVC=0.40,CLI=0.0,ALPHAI=0.0,CLALPA(1)=6*.131,
CLMAX(1)=6*.82,CMO=0.0,LERI=.0025,CLAMO=.105$
$VTPLNF CHRDTP=.420,SSPNE=.63,SSPN=.849,CHDR=1.02,SAVSI=28.1,
CHSTAT=.25,SWAPP=0.0,TWISTA=0.0,TYPE=1.0$
$VTSCHR TOVC=.09,XOVC=0.40,CLALPA(1)=6*.141,LERI=.0075$

```

CASEID PLOT TEST PROBLEM 1, CASE 1

SAVE

PLOT

NEXT CASE

```

$SYNPLP FTYPE=1.,NDELTA=7.,DELTA(1)=0.,2.,5.,10.,15.,20.,25.,PHETE=0.05,
PHETEP=0.05,SPANFI=0.2,SPANFO=0.7,CHRDPI=0.075,CHRDFO=0.05,
CB=0.004,TC=0.075,NTYPE=1., $

```

CASEID PLOT TEST PROBLEM 1, CASE 2

PLOT

NEXT CASE

```

$PLITCON NALPHA=9.0,ALSCHD=-2.0,0.0,2.0,4.0,8.0,
12.0,16.0,20.0,24.0$
$FLTCO NMAC=6.0,MACH(1)=0.1,0.2,0.3,0.4,0.5,0.6,RNNUB(1)=6*4.26E6,$
$OPTINS SREF=2.25,CBARR=0.822,BLREF=3.00$
$SYNTHS XCG=2.60,ZCG=0.0,XW=1.70,ZW=0.0,ALIW=0.0,XH=3.93,ZH=0.0,
ALIH=0.0,XV=3.34,VERTUP=.TRUE., $
$BODY NX=10.0,BNOSE=2.0,BTAIL=1.0,BLN=1.46,BLA=1.97,
X(1)=0.0,.175,.322,.530,.85,1.46,2.50,3.43,3.97,4.57,
R(1)=0.0,.0417,.0833,.125,.1665,.208,.208,.208,.178,.138$
$WGPLNF CHRDTP=0.346,SSPNE=1.05,SSPN=1.26,CHDR=1.16,SAVSI=45.0,CHSTAT=.25,
SWAPP=0.0,TWISTA=0.0,SSPND=0.0,DHDADI=0.0,DHDADO=0.0,TYPE=1.0$
$WGSCHR TOVC=.060,DELTAY=1.30,XOVC=0.40,CLI=0.0,ALPHAI=0.0,CLALPA(1)=6*.131,
CLMAX(1)=6*.82,CMO=0.0,LERI=0.0025,CLAMO=.105$
$HTPLNF CHRDTP=.253,SSPNE=.52,SSPN=.67,CHDR=.42,SAVSI=45.0,CHSTAT=0.25,
SWAPP=0.0,TWISTA=0.0,SSPND=0.0,DHDADI=0.0,DHDADO=0.0,TYPE=1.0$
$HTSCHR TOVC=.060,DELTAY=1.30,XOVC=0.40,CLI=0.0,ALPHAI=0.0,CLALPA(1)=6*.131,
CLMAX(1)=6*.82,CMO=0.0,LERI=.0025,CLAMO=.105$
$VTPLNF CHRDTP=.420,SSPNE=.63,SSPN=.849,CHDR=1.02,SAVSI=28.1,
CHSTAT=.25,SWAPP=0.0,TWISTA=0.0,TYPE=1.0$
$VTSCHR TOVC=.09,XOVC=0.40,CLALPA(1)=6*.141,LERI=.0075$

```

CASEID PLOT TEST PROBLEM 2, CASE 1

SAVE

PLOT

NEXT CASE

```

$SYNTHS HINAX=4.271, $

```

TRIM

CASEID PLOT TEST PROBLEM 2, CASE 2

PLOT

NEXT CASE

PROBLEM 1

PROBLEM 2

FIGURE 11 DIGITAL DATCOM PLOT PROBLEMS

| | |
|--------------------------------------|--------|
| TITLE1 26 PLOT MODULE SAMPLE PROBLEM | |
| TITLE2 6 CASE 1 | CASE 1 |
| MACH 5 | |
| BUILD ALL | |
| NEXT CASE | |
| TITLE1 26 PLOT MODULE SAMPLE PROBLEM | |
| TITLE2 6 CASE 2 | CASE 2 |
| FILE B 12 1 | |
| LINE A 1 0 | |
| LINE B -1 1 | |
| GROUP -2 | |
| GROUP -3 | |
| GROUP -4 | |
| MACH 5 | |
| BUILD W, BWHV | |
| SAVE | |
| NEXT CASE | |
| TITLE2 6 CASE 3 | CASE 3 |
| GROUP 1 | |
| PLOT -2 | |
| PLOT -3 | |
| PLOT 1 | |
| SCALE X -2.0 12.0 | |
| SCALE Y 0.0 0.12 | |
| LABEL Y 2CD | |
| GRID 0 | |
| SAVE | |
| NEXT CASE | |
| TITLE2 6 CASE 4 | CASE 4 |
| BUILD | |
| GROUP -1 | |
| GROUP 4 | |
| PLOT -2 | |
| PLOT -3 | |
| SAVE | |
| NEXT CASE | |

FIGURE 12 SAMPLE PLOT INPUT DATA

TITLE2 6 CASE 5

FILE A 12 2

FILE B 0 1

LINE A 1 0

GROUP -4

GROUP 7

PLOT 7

PLOT 8

PLOT 9

GROUP 1

PLOT 2

PLOT 3

PLOT 1

LABEL Y 16DRAG COEFFICIENT

SCALE X 1.0E-60 1.0E-60

SCALE Y 1.0E-60 1.0E-60

GRID -1

BUILD NONE

NEXT CASE

TITLE1 26 PLOT MODULE SAMPLE PROBLEM

TITLE2 6 CASE 6

FILE A 11 2

LINE A 0 2

MACH 5

GROUP -1

GROUP -2

GROUP -3

GROUP -4

GROUP 5

PLOT 1

PLOT 2

GRID

END

CASE 5

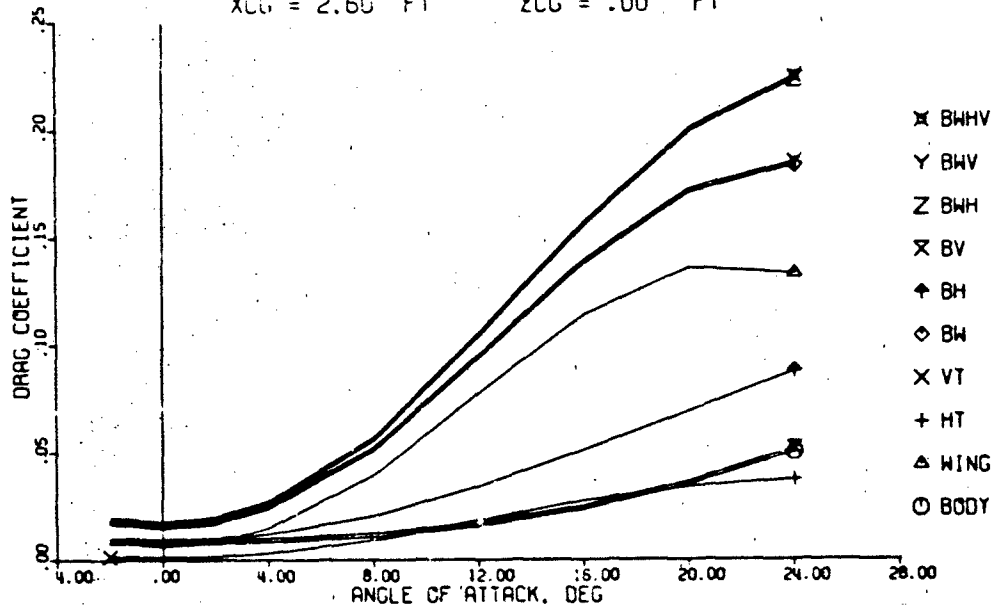
CASE 6

FIGURE 12 SAMPLE PLOT INPUT DATA (CONTINUED)

PLOT MODULE SAMPLE PROBLEM

CASE 1

MACH NO. = .50 REYNOLDS NO. = 3.50×10^6
 SREF = 2.250 FT CBAR = .822 FT SPAN = 3.000 FT
 XCG = 2.60 FT ZCG = .00 FT



PLOT MODULE SAMPLE PROBLEM

CASE 1

MACH NO. = .50 REYNOLDS NO. = 3.50×10^6
 SREF = 2.250 FT CBAR = .822 FT SPAN = 3.000 FT
 XCG = 2.60 FT ZCG = .00 FT

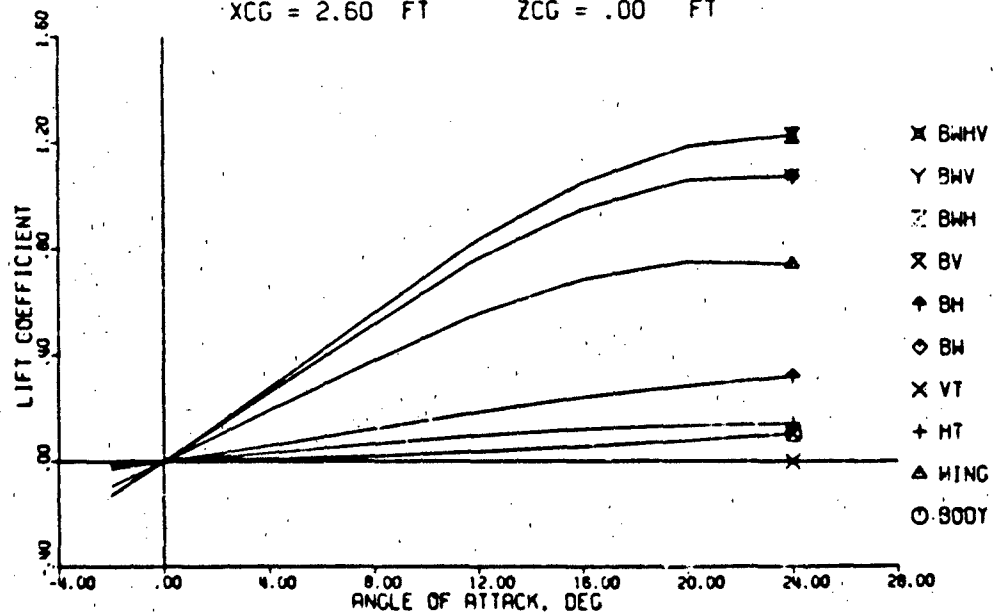
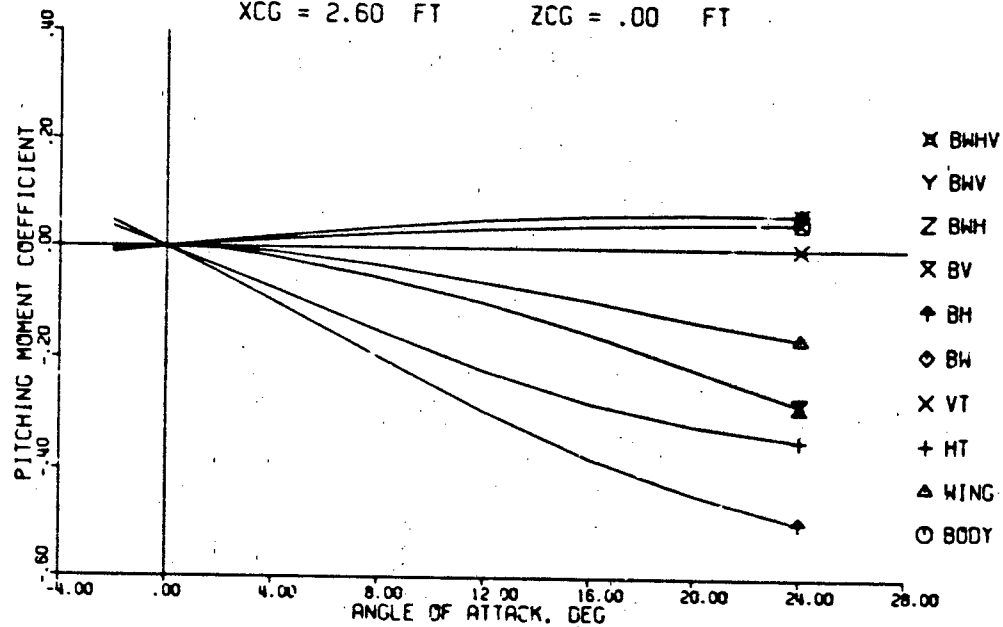


FIGURE 13 SAMPLE CASE 1 PLOTS

PLOT MODULE SAMPLE PROBLEM

CASE 1

MACH NO. = .50 REYNOLDS NO. = 3.50×10^6
 SREF = 2.250 FT CBAR = .822 FT SPAN = 3.000 FT
 XCG = 2.60 FT ZCG = .00 FT



PLOT MODULE SAMPLE PROBLEM

CASE 1

MACH NO. = .50 REYNOLDS NO. = 3.50×10^6
 SREF = 2.250 FT CBAR = .822 FT SPAN = 3.000 FT
 XCG = 2.60 FT ZCG = .00 FT

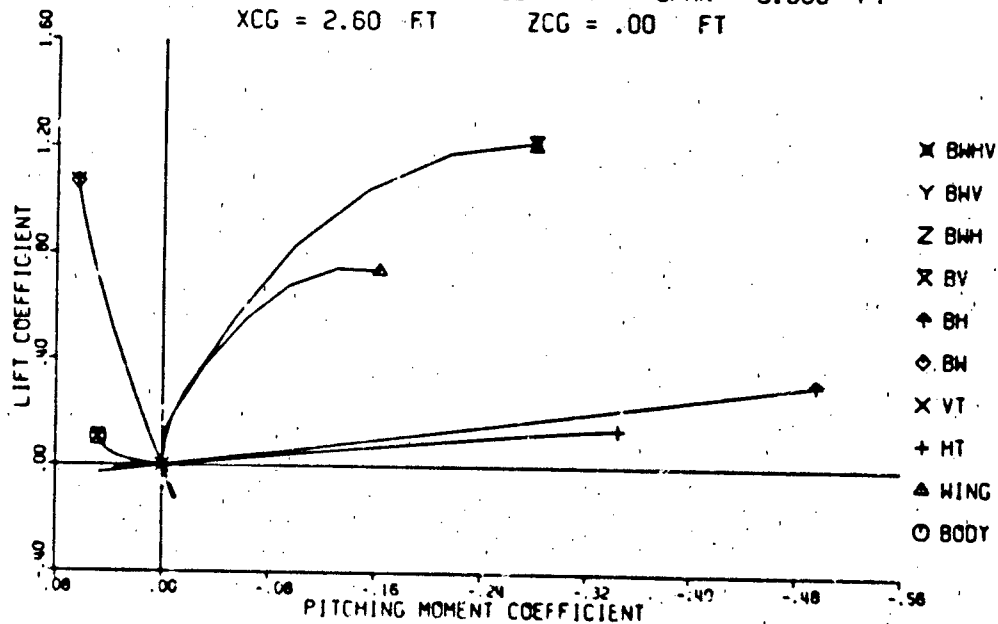
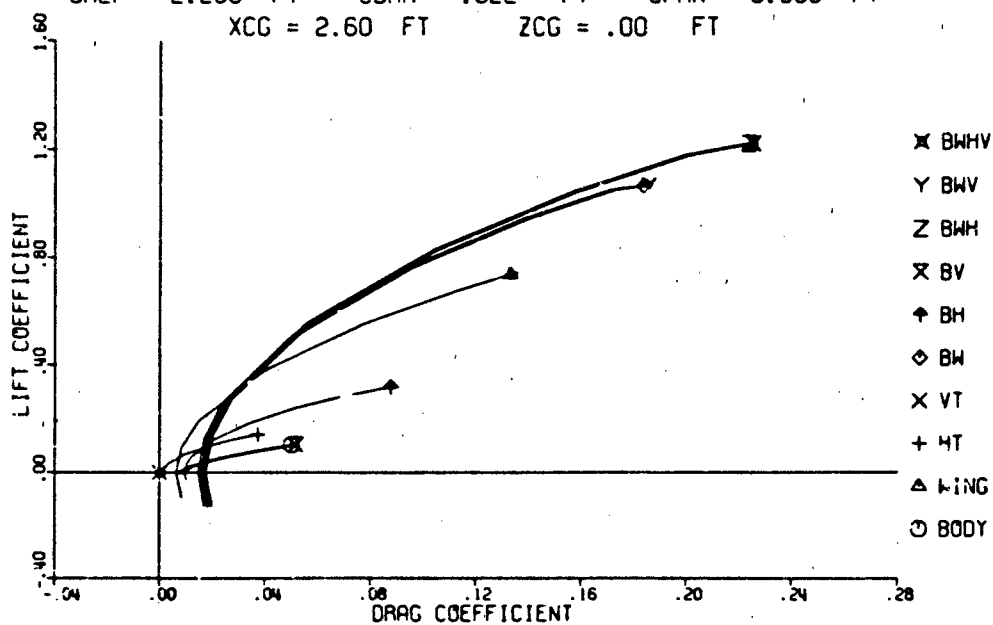


FIGURE 13 SAMPLE CASE 1 PLOTS (CONTINUED)

PLOT MODULE SAMPLE PROBLEM

CASE 1

MACH NO. = .50 REYNOLDS NO. = 3.50×10^6
 SREF = 2.250 FT CBAR = .822 FT SPAN = 3.000 FT
 XCG = 2.60 FT ZCG = .00 FT



PLOT MODULE SAMPLE PROBLEM

CASE 1

MACH NO. = .50 REYNOLDS NO. = 3.50×10^6
 SREF = 2.250 FT CBAR = .822 FT SPAN = 3.000 FT
 XCG = 2.60 FT ZCG = .00 FT

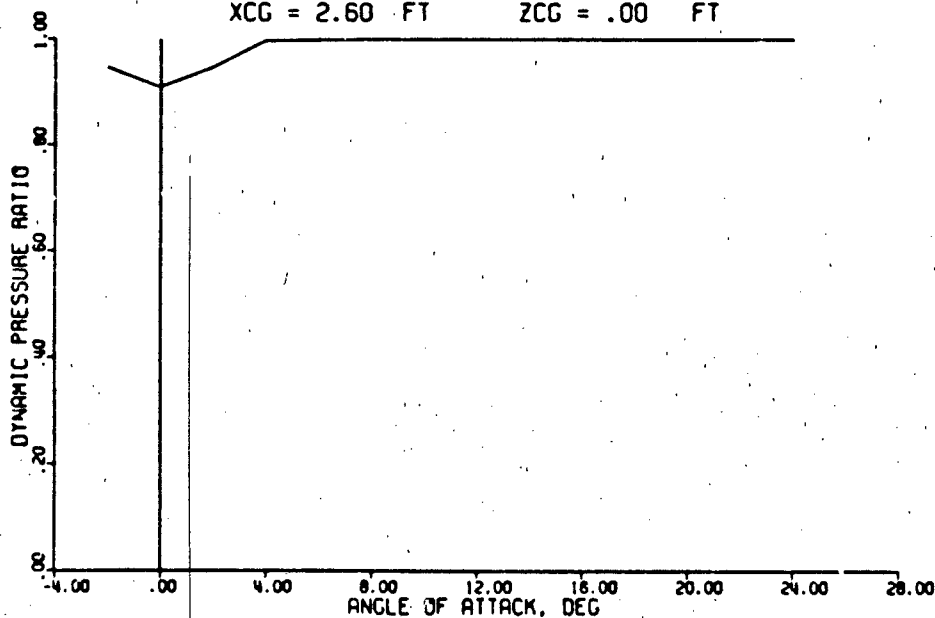
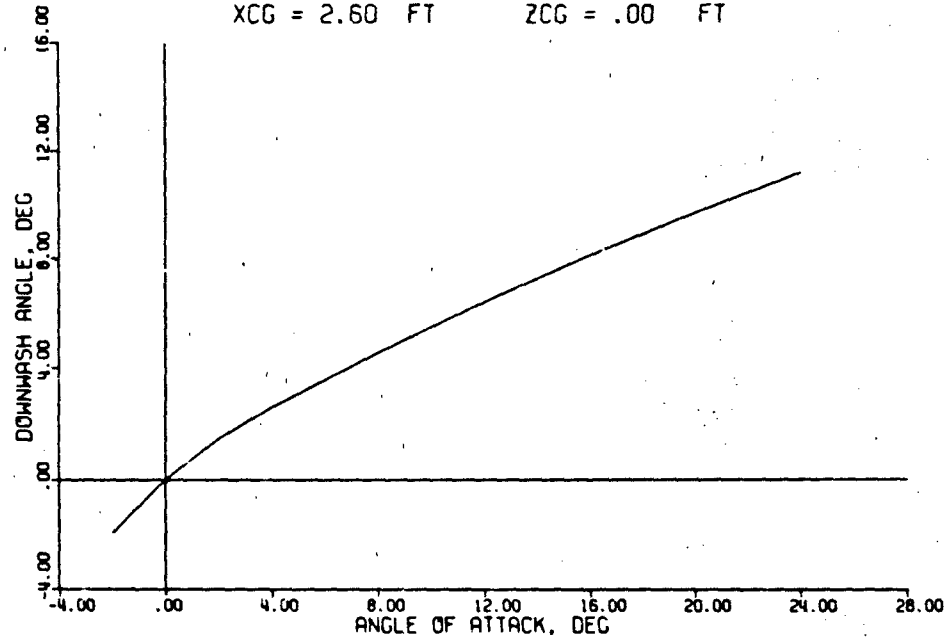


FIGURE 13 SAMPLE CASE 1 PLOTS (CONTINUED)

PLOT MODULE SAMPLE PROBLEM

CASE 1

MACH NO. = .50 REYNOLDS NO. = 3.50×10^6
 SREF = 2.250 FT CBAR = .822 FT SPAN = 3.000 FT
 XCG = 2.60 FT ZCG = .00 FT



PLOT MODULE SAMPLE PROBLEM

CASE 1

MACH NO. = .50 REYNOLDS NO. = 3.50×10^6
 SREF = 2.250 FT CBAR = .822 FT SPAN = 3.000 FT
 XCG = 2.60 FT ZCG = .00 FT

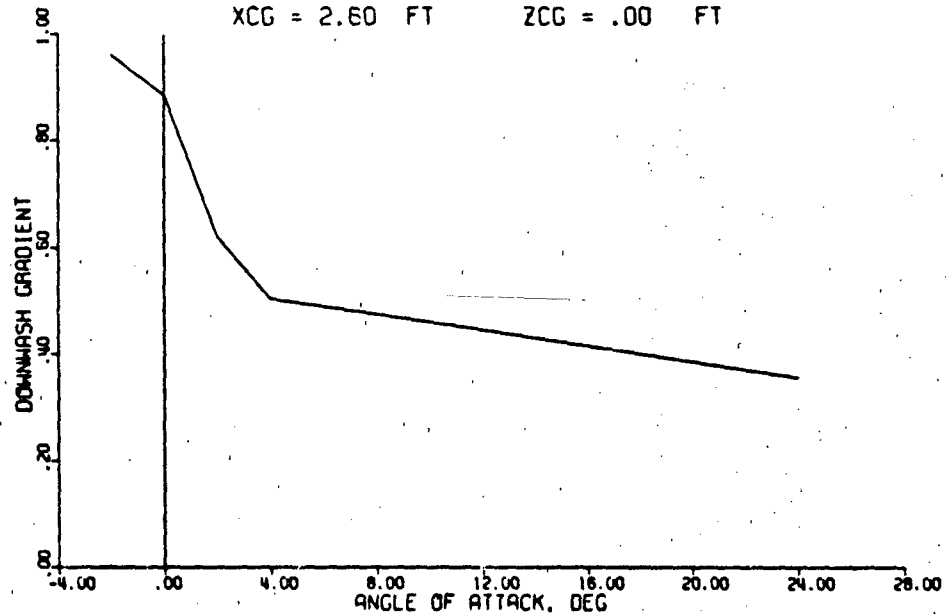


FIGURE 13 SAMPLE CASE 1 PLOTS (CONTINUED)

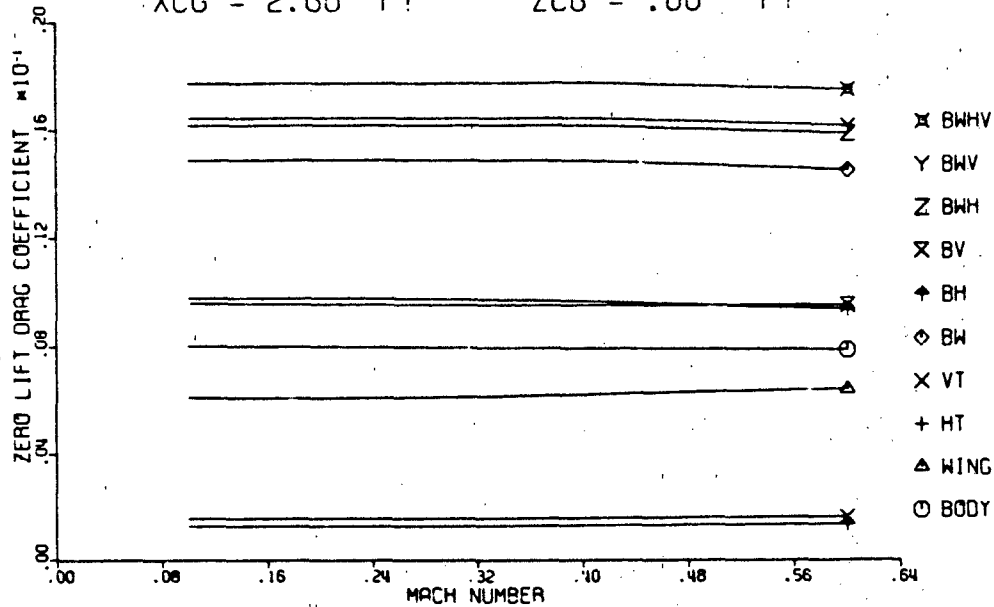
PLOT MODULE SAMPLE PROBLEM

CASE 1

ALTITUDE = 0 FT

SREF = 2.250 FT CBAR = .822 FT SPAN = 3.000 FT

XCG = 2.60 FT ZCG = .00 FT



PLOT MODULE SAMPLE PROBLEM

CASE 1

ALTITUDE = 0 FT

SREF = 2.250 FT CBAR = .822 FT SPAN = 3.000 FT

XCG = 2.60 FT ZCG = .00 FT

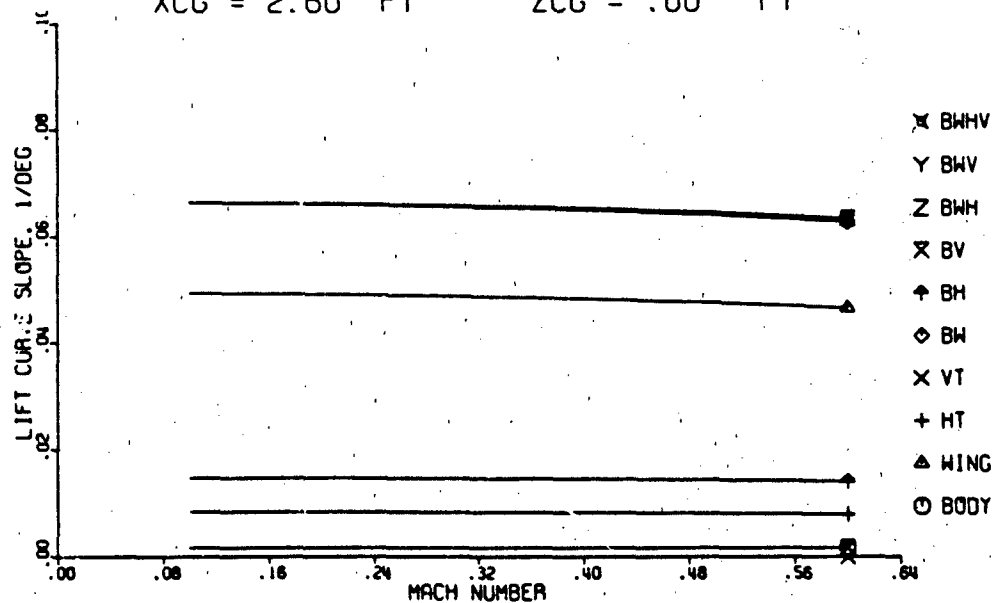


FIGURE 13 SAMPLE CASE 1 PLOTS (CONTINUED)

PLOT MODULE SAMPLE PROBLEM
CASE 1
ALTITUDE = 0 FT
SREF = 2.250 FT CBAR = .822 FT SPAN = 3.000 FT
XCG = 2.60 FT ZCG = .00 FT

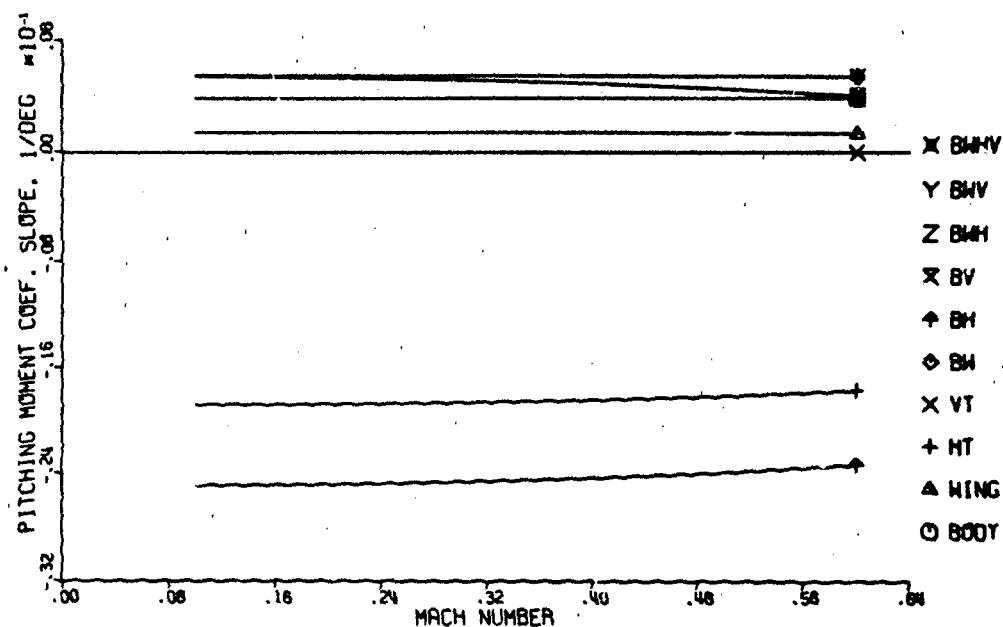
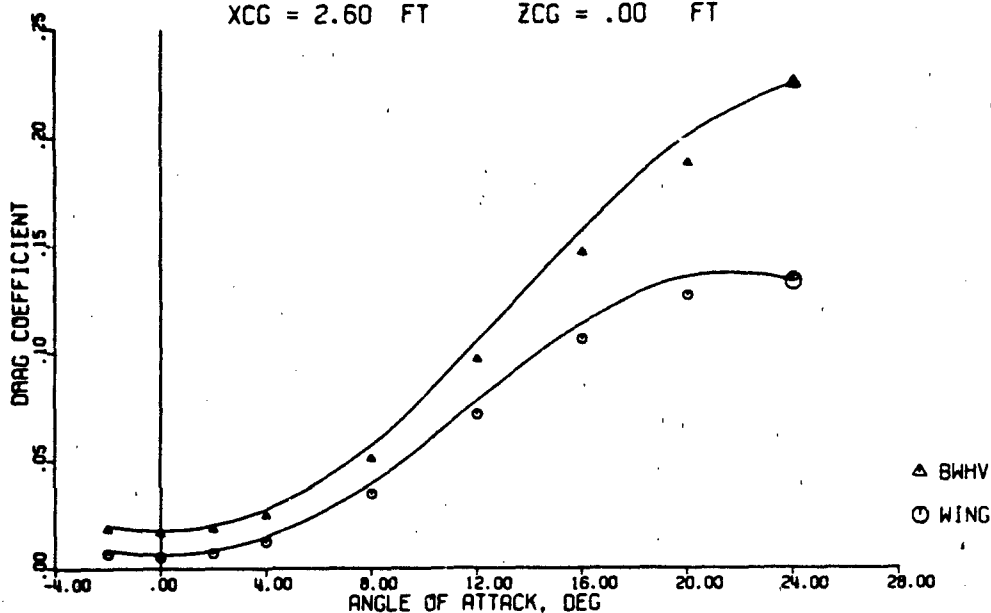


FIGURE 13 SAMPLE CASE 1 PLOTS (CONTINUED)

PLOT MODULE SAMPLE PROBLEM

CASE 2

MACH NO. = .50 REYNOLDS NO. = 3.50×10^6
 SREF = 2.250 FT CBAR = .822 FT SPAN = 3.000 FT
 XCG = 2.60 FT ZCG = .00 FT



PLOT MODULE SAMPLE PROBLEM

CASE 2

MACH NO. = .50 REYNOLDS NO. = 3.50×10^6
 SREF = 2.250 FT CBAR = .822 FT SPAN = 3.000 FT
 XCG = 2.60 FT ZCG = .00 FT

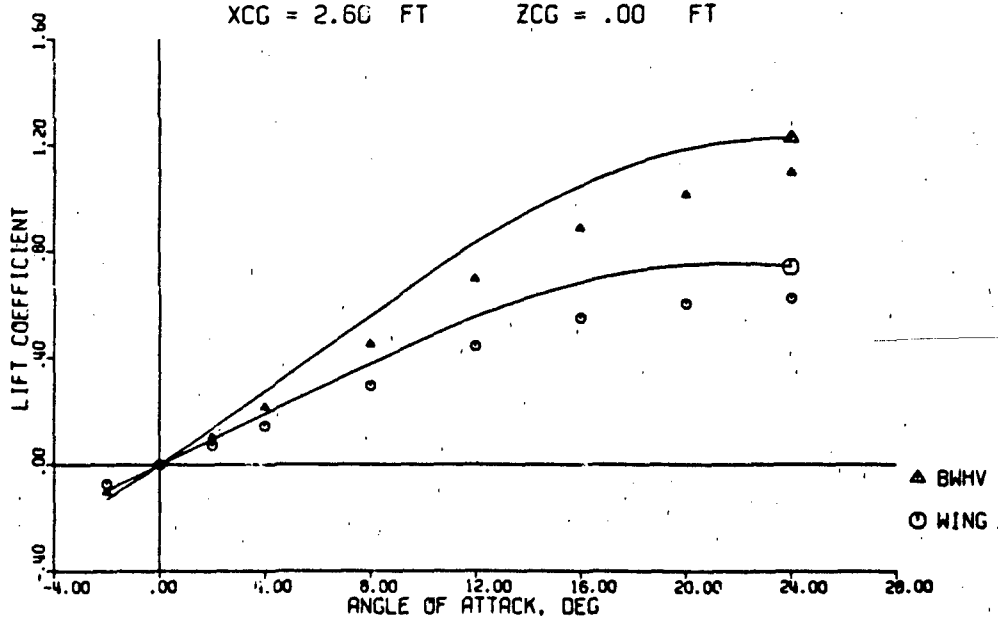


FIGURE 14 SAMPLE CASE 2 PLOTS

PLOT MODULE SAMPLE PROBLEM

CASE 2

MACH NO. = .50 REYNOLDS NO. = 3.50×10^6
 SREF = 2.250 FT CBAR = .822 FT SPAN = 3.000 FT
 XCG = 2.60 FT ZCG = .00 FT

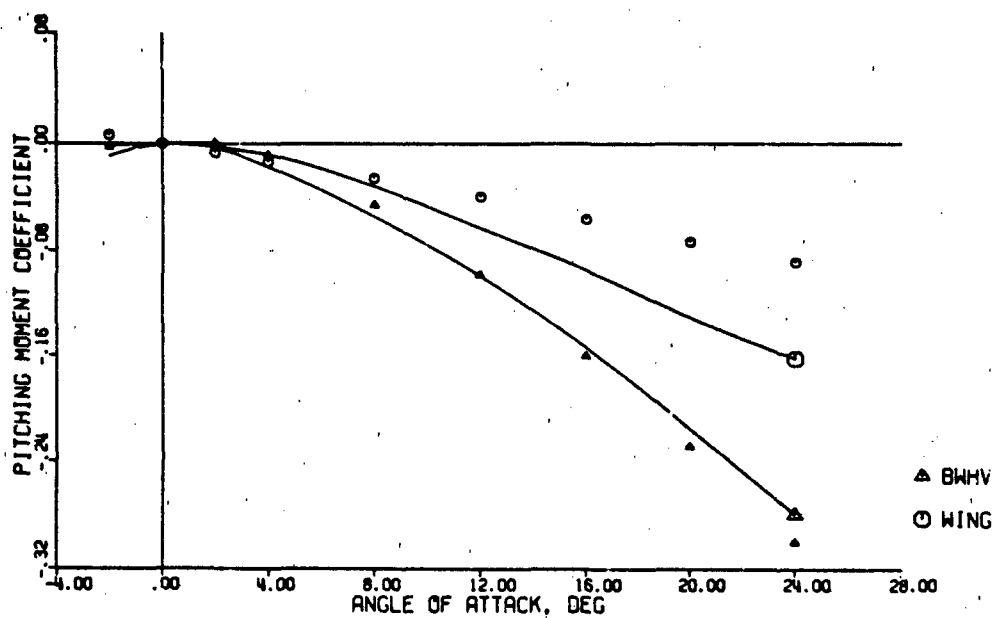


FIGURE 14 SAMPLE CASE 2 PLOTS (CONTINUED)

PLOT MODULE SAMPLE PROBLEM

CASE 3

MACH NO. = .50 REYNOLDS NO. = 3.50×10^6
 SREF = 2.250 FT CBAR = .822 FT SPAN = 3.000 FT
 XCG = 2.60 FT ZCG = .00 FT

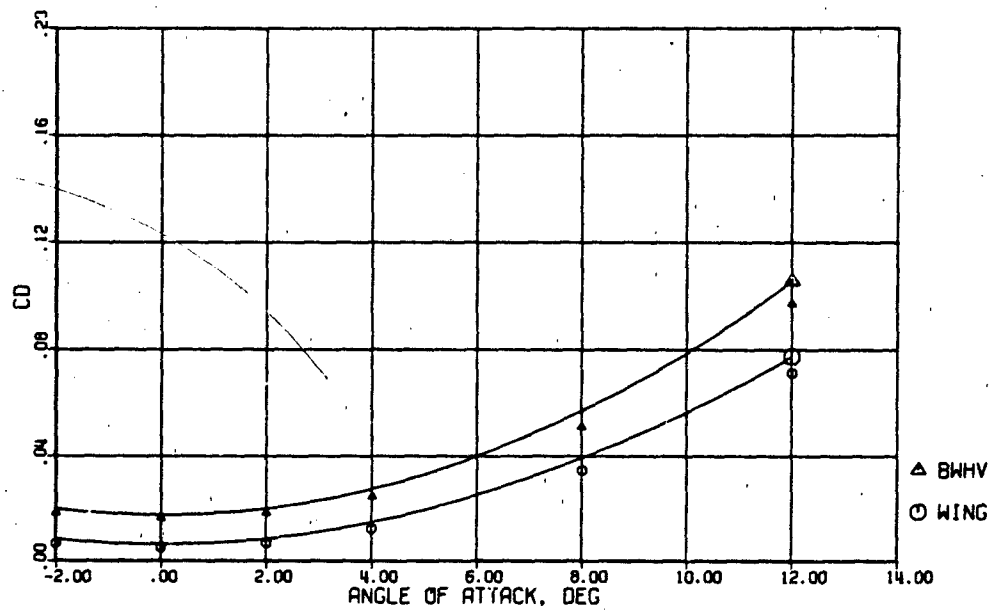


FIGURE 15 SAMPLE CASE 3 PLOT

PLOT MODULE SAMPLE PROBLEM

CASE 4

ALTITUDE = 0 FT

SREF = 2.250 FT CBAR = .822 FT SPAN = 3.000 FT

XCG = 2.60 FT ZCG = .00 FT

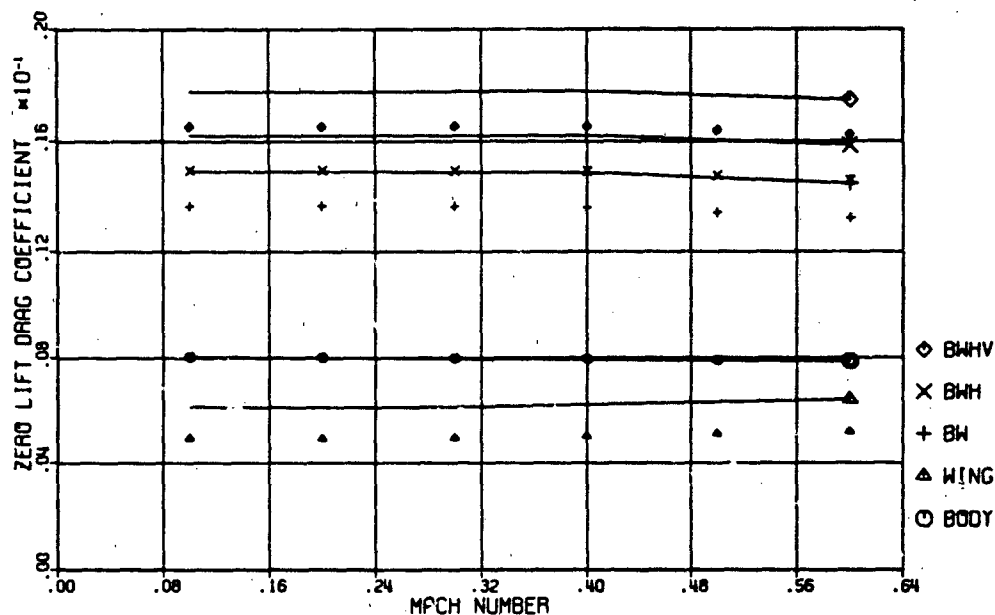
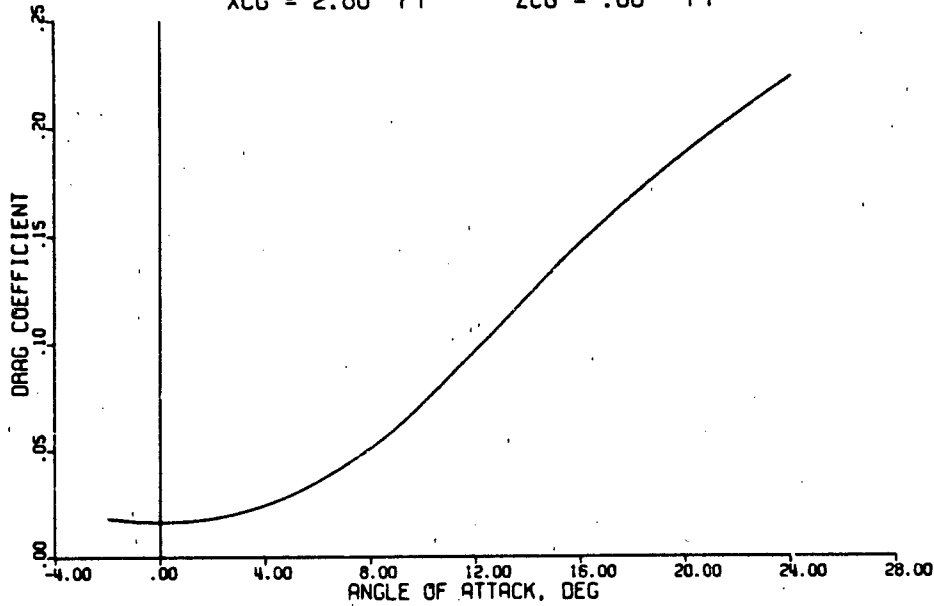


FIGURE 16 SAMPLE CASE 4 PLOT

PLOT MODULE SAMPLE PROBLEM

CASE 5

MACH NO. = .50 REYNOLDS NO. = 3.50×10^6
 SREF = 2.250 FT CBAR = .822 FT SPAN = 3.000 FT
 XCG = 2.60 FT ZCG = .00 FT



PLOT MODULE SAMPLE PROBLEM

CASE 5

MACH NO. = .50 REYNOLDS NO. = 3.50×10^6
 SREF = 2.250 FT CBAR = .822 FT SPAN = 3.000 FT
 XCG = 2.60 FT ZCG = .00 FT

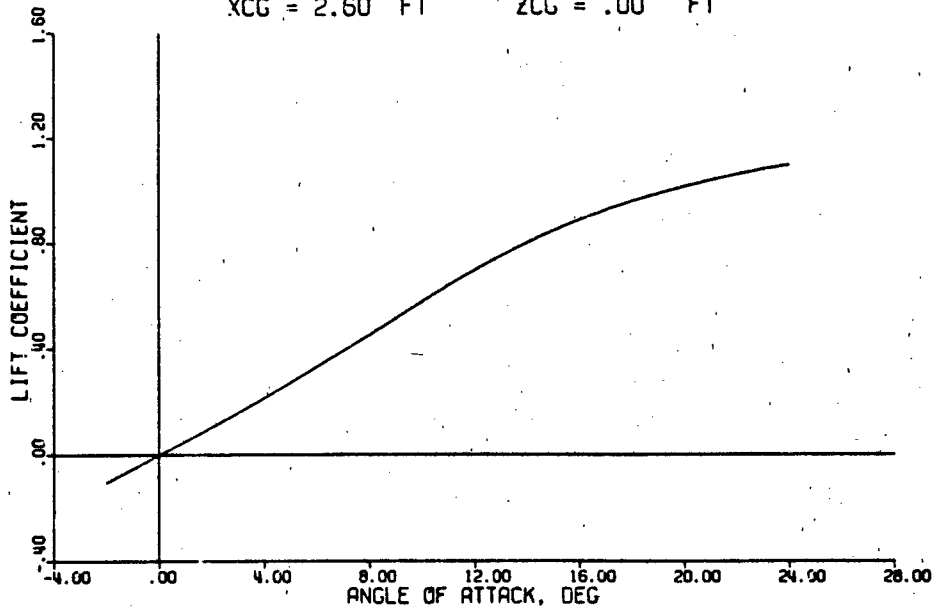
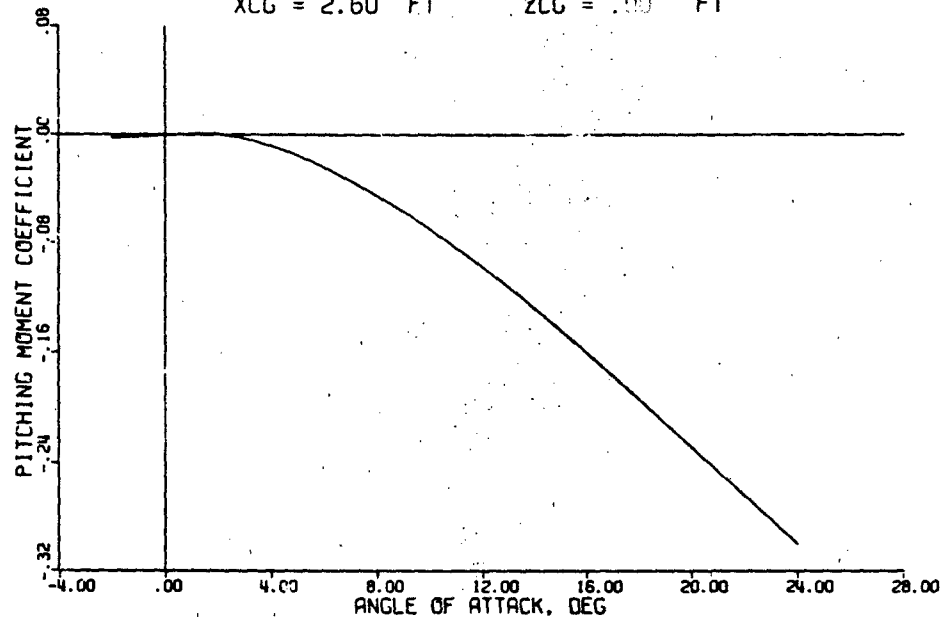


FIGURE 17 SAMPLE CASE 5 PLOTS

PLOT MODULE SAMPLE PROBLEM

CASE 5

MACH NO. = .50 REYNOLDS NO. = 3.50×10^6
 SREF = 2.250 FT CBAR = .822 FT SPAN = 3.000 FT
 XCG = 2.60 FT ZCG = .00 FT



PLOT MODULE SAMPLE PROBLEM

CASE 5

MACH NO. = .50 REYNOLDS NO. = 3.50×10^6
 SREF = 2.250 FT CBAR = .822 FT SPAN = 3.000 FT
 XCG = 2.60 FT ZCG = .00 FT

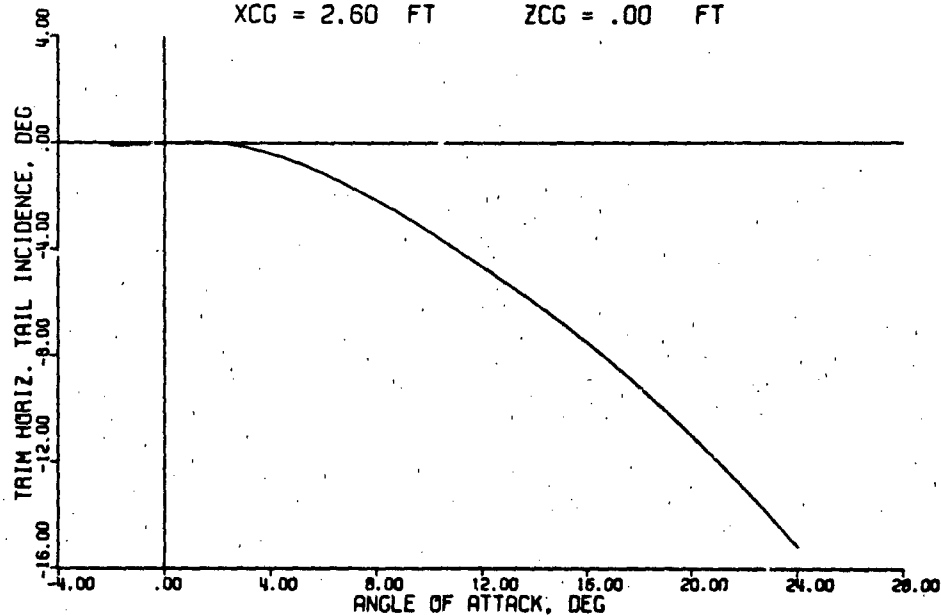
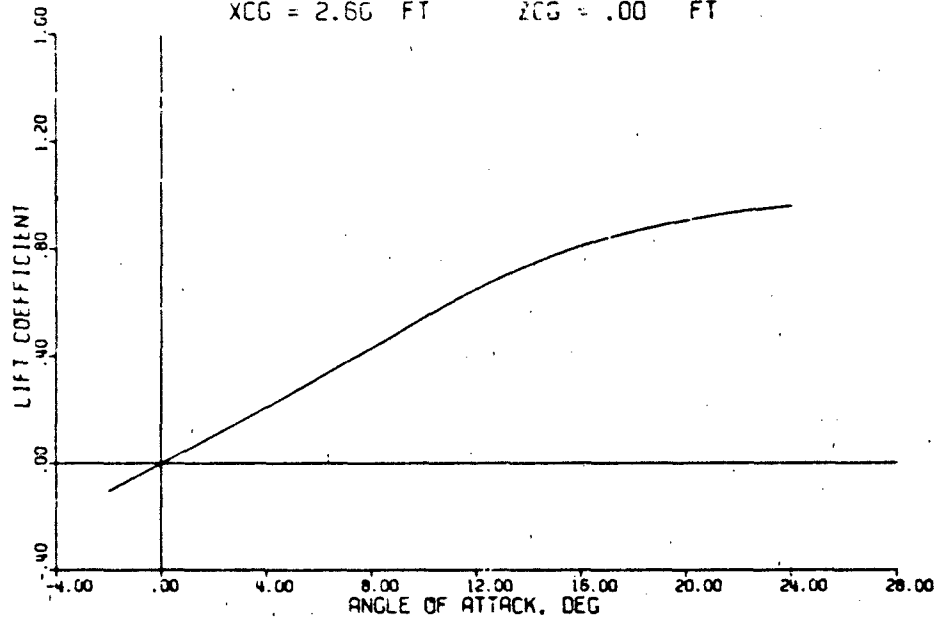


FIGURE 17 SAMPLE CASE 5 PLOTS (CONTINUED)

PLOT MODULE SAMPLE PROBLEM

CASE 5

MACH NO. = .50 REYNOLDS NO. = 3.50×10^6
 SREF = 2.250 FT CBAR = .822 FT SPAN = 3.000 FT
 XCG = 2.60 FT ZCG = .00 FT



PLOT MODULE SAMPLE PROBLEM

CASE 5

MACH NO. = .50 REYNOLDS NO. = 3.50×10^6
 SREF = 2.250 FT CBAR = .822 FT SPAN = 3.000 FT
 XCG = 2.60 FT ZCG = .00 FT

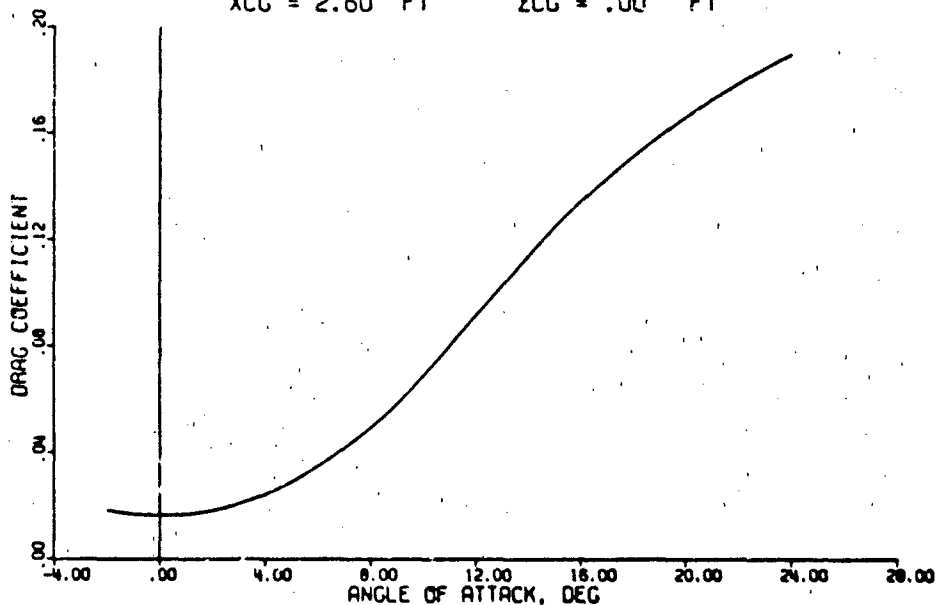
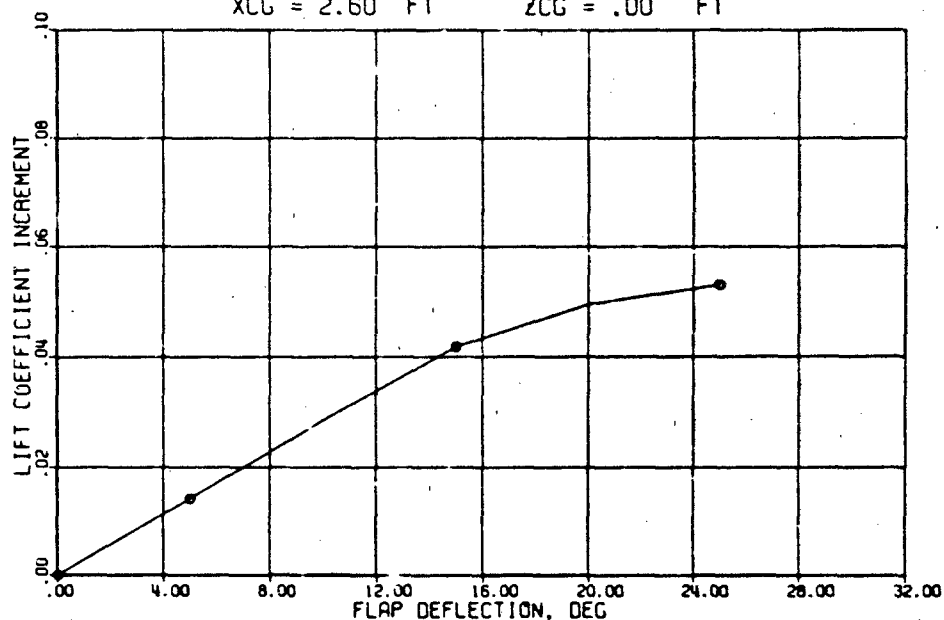


FIGURE 17 SAMPLE CASE 5 PLOTS (CONTINUED)

PLOT MODULE SAMPLE PROBLEM

CASE 6

MACH NO. = .50 REYNOLDS NO. = 3.50×10^6
 SREF = 2.250 FT CBAR = .822 FT SPAN = 3.000 FT
 XCG = 2.60 FT ZCG = .00 FT



PLOT MODULE SAMPLE PROBLEM

CASE 6

MACH NO. = .50 REYNOLDS NO. = 3.50×10^6
 SREF = 2.250 FT CBAR = .822 FT SPAN = 3.000 FT
 XCG = 2.60 FT ZCG = .00 FT

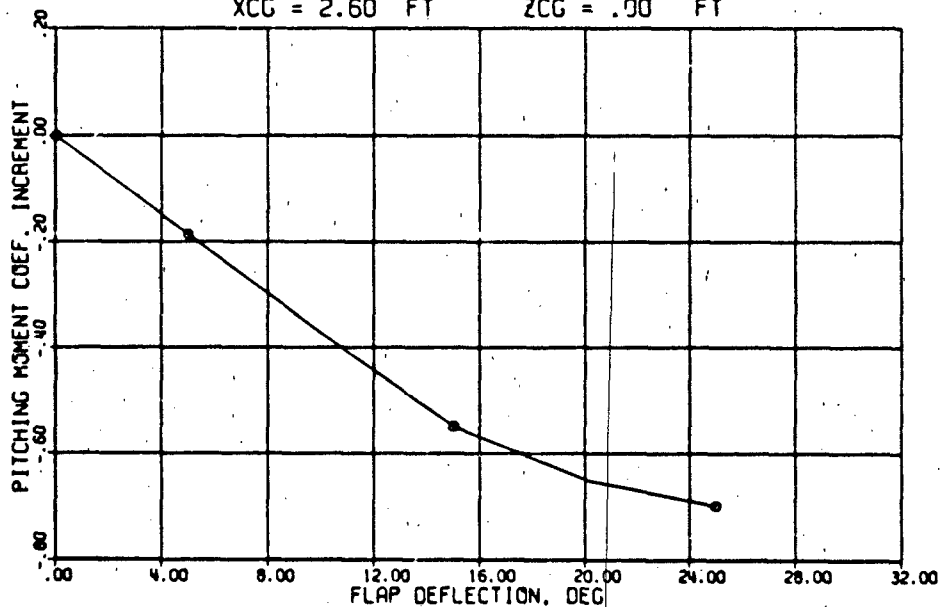


FIGURE 18 SAMPLE CASE 6 PLOTS

SECTION 5

PROGRAM STRUCTURE

The Digital Datcom plot module was written in Fortran IV for the CDC Cyber 74 and 175 computer systems. Users should refer to Section 6 of Volume II when implementing this module on another computer system.

5.1 SYSTEM RESOURCE REQUIREMENTS

The plot module requires the availability of certain computer resources and capabilities in order to operate. These resources are:

- o Seven disk or tape files are required for manipulation and processing of data. The logical I/O units are 8 through 14 and are in addition to the system input and output, assigned to I/O units 5 and 6 respectively.
- o The system should have an overlay capability, however, the plot module could operate without this capability.
- o The system must have a Fortran compiler that provides statement transfer when an end of file is encountered.

Each logical I/O unit used by this module is reserved for a specific purpose. These units and their use by the program are listed below.

| <u>Unit</u> | <u>Program Usage</u> |
|-------------|--|
| 5 | Standard system input (card reader). |
| 6 | Standard system output (printer). |
| 8 | Temporary storage for input data. |
| 9 | Temporary storage for Mach effects data. |
| 10 | Plot tape. |
| 11 | Digital Datcom plot data file. |
| 12 | Digital Datcom plot data file. |
| 13 | Digital Datcom plot data file. |
| 14 | Digital Datcom plot data file. |

5.2 PROGRAM DESCRIPTION

The plot module overlay structure is composed of a root segment (overlay 0) and ten primary overlays. Table 1 shows the overall program structure and

lists the routines in each overlay. Table 2 lists each routine, the overlay where it is referenced, and a brief description of its purpose. A complete listing of each routine is provided as a microfiche supplement to this report.

5.3 DIGITAL DATCOM PLOT FILE STRUCTURE

A Digital Datcom plot file is written to I/O unit 13 when the PLOT control card is present in a case, see Volume I. This file contains Digital Datcom case data (described below) and aerodynamic data for each Mach number and altitude combination computed by the program. The aerodynamic data consists of the first 200 elements of each Ideal Output Matrix (IOM) data block, the zero lift drag of each component combination in the IOM, and flap input and IOM arrays when flap or trim data are calculated. If the user generates a plot file containing data from wind tunnel test of other sources, those elements in the file that are defined should contain the program value of UNUSED (1×10^{-60} on CDC systems). The specific data in the Digital Datcom plot file and the format used to write it are given below.

5.3.1 Digital Datcom Case Data

The Digital Datcom case data consists of the flight condition inputs (160 elements), synthesis inputs (15 elements), reference parameter inputs (4 elements), and the logical flags in the Digital Datcom common block FL0L0G (34 elements). A definition of the data in common block FL0L0G is given in Volume II, Section 7, Table 10. The flight condition inputs are supplied to Digital Datcom through namelist FLTC0N and are defined in Volume I, Figure 3. The synthesis parameters are input through namelist SYNTHS (Volume I, Figure 5) and the reference parameters through namelist OPTINS (Volume I, Figure 4). The common block FL0L0G is defined in Volume II, Section 7. All of the input data are written with the format "IPI0E12.4" and the logical flags (FL0L0G) are written with the format "34L3". The case data then consists of:

1. flight condition data, 16 lines with 10 elements on each line;
2. synthesis data, 2 lines with 10 elements on the first line and 5 on the second;
3. reference parameters, 1 line with 4 elements; and
4. Digital Datcom logical flags, 1 line with 34 elements.

5.3.2 Digital Datcom Aerodynamic Data

One set of aerodynamic data is written for every Mach number - altitude combination executed by Digital Datcom. Each set of aerodynamic data

consists of the basic stability data, zero lift drag data, and flap data if flap or trim computations are performed. All of these data are written using the format "1P10E12.4". The basic stability data consists of the first 200 elements of the 11 IOM common blocks IBODY, IWING, IHT, IVT, IVF, IBW, IBH, IBV, IBWH, IBWV, and IBWHV plus 100 elements of downwash data from IOM common block IDWASH and the canard effective downwash data in common block FACT. Each of these common blocks are defined in Volume I, Appendix C. The zero lift drag data consists of one value for each of the 11 component combinations in the IOM. The flap data consists of the final 200 elements of the IOM common blocks IBODY and IWING plus the final 180 elements of the blocks IHT and IVT. One set of aerodynamic data will consist of:

1. basic stability data, 230 lines with 10 elements on each line;
2. zero lift drag data, 2 lines with 10 elements on the first line;
and
3. flap data if trim, symmetrical flaps or asymmetrical flaps are present, 76 lines with 10 elements on each line.

TABLE 1 DIGITAL DAYCOM PLOT MODULE OVERLAY DESCRIPTION

| OVERLAY | PROGRAM/SUBROUTINE NAME | OVERLAY DESCRIPTION |
|---------|-------------------------------------|---------------------------|
| 0 | MAIN BLOCK DATA CPLØT WAIT | TOP LEVEL PROGRAM CONTROL |
| 1 | DRAW1 DRAW | DRAWS GROUP 1 PLOTS |
| 2 | DRAW2 DRAW | DRAW2 GROUP 2 PLOTS |
| 3 | DRAW3 DRAW | DRAWS GROUP 3 PLOTS |
| 4 | DRAW4 DRAW | DRAWS GROUP 4 PLOTS |
| 5 | DRAW5 DRAW | DRAWS GROUP 5 PLOTS |
| 6 | DRAW6 DRAW | DRAWS GROUP 6 PLOTS |
| 7 | DRAW7 DRAW | DRAWS GROUP 7 PLOTS |

TABLE 1 DIGITAL DATCOM PLOT MODULE OVERLAY DESCRIPTION

| OVERLAY | PROGRAM/SUBROUTINE NAME | OVERLAY DESCRIPTION |
|---------|--------------------------------|-------------------------------|
| 8 | INITZE | PROGRAM INITIALIZATION |
| 9 | INPUT | READ PLOT CONTROL CARDS |
| 10 | TEST RBUILD READ SKIP | READ DIGITAL DATCOM PLOT DATA |

TABLE 2 DIGITAL DATCOM PLOT MODULE ROUTINE DESCRIPTION

| ROUTINE NAME | OVERLAYS REFERENCED | DESCRIPTION |
|-----------------|------------------------|--|
| MAIN | 0 | TOP LEVEL OF PLOT MODULE |
| BLØCK DATA | 0 | SET DATA CONSTANTS |
| CPLØT | 0 | CONTROL PLOT SEQUENCE |
| WAIT | 0 | DRAW PLOT CORNERS AND RE-ORIGIN |
| DRAW1 | 1 | PREPARES DATA FOR PLOT GROUP 1 |
| DRAW | 1, 2, 3, 4, 5, 6, 7 | ROUTINE WHICH SCALES DATA, DRAWS AXES, DRAWS GRID, DRAWS CURVES, AND LABELS THE PLOT AND THE CURVES |
| DRAW 2 | 2 | PREPARES DATA FOR PLOT GROUP 2 |
| DRAW 3 | 3 | PREPARES DATA FOR PLOT GROUP 3 |
| DRAW 4 | 4 | PREPARES DATA FOR PLOT GROUP 4 |
| DRAW 5 | 5 | PREPARES DATA FOR PLOT GROUP 5 |
| DRAW 6 | 6 | PREPARES DATA FOR PLOT GROUP 6 |
| DRAW 7 | 7 | PREPARES DATA FOR PLOT GROUP 7 |
| INITIZE | 8 | PROGRAM INITIALIZATION |
| INPUT | 9 | READ PLOT CONTROL CARDS AND SET PLOTTING FLAGS |
| TEST | 9 | ROUTINE TESTS FOR VALID CONTROL CARD INPUT |
| RBUILD | 9 | ROUTINE READS BUILD CARD |
| READ | 10 | READ DIGITAL DATCOM DATA |
| SKIPC | 10 | ROUTINE POSITIONS INPUT DATA FILE TO THE APPROPRIATE CASE TO BE PLOTTED |

TABLE 3 CHARACTERS AVAILABLE IN SUBROUTINE SYMBOL

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|-----|---|-----|---|-----|---|-----|---|-----|---|-----|---|-----|---|-----|---|-----|---|-----|---|-----|----|-----|---|-----|---|-----|---|-----|---|
| 135 | π | 136 | ρ | 137 | τ | 138 | ℓ | 139 | ν | 140 | φ | 141 | χ | 142 | ψ | 143 | ℓ | 144 | θ | 145 | H | 146 | Υ | 147 | Ψ | 148 | Ω | | |
| 120 | Π | 121 | Φ | 122 | Ψ | 123 | Ω | 124 | Σ | 125 | ∫ | 126 | ° | 127 | ⋈ | 128 | δ | 129 | ε | 130 | Σ | 131 | η | 132 | θ | 133 | ν | 134 | Ξ |
| 105 | ○ | 106 | π | 107 | ρ | 108 | σ | 109 | τ | 110 | ν | 111 | φ | 112 | χ | 113 | ψ | 114 | ω | 115 | † | 116 | Δ | 117 | θ | 118 | Λ | 119 | Ξ |
| 90 | ° | 91 | α | 92 | β | 93 | ⋈ | 94 | δ | 95 | ε | 96 | ζ | 97 | η | 98 | θ | 99 | ι | 100 | κ | 101 | λ | 102 | μ | 103 | ν | 104 | ξ |
| 75 | # | 76 | ℓ | 77 | ℓ | 78 | ‰ | 79 | ι | 80 | — | 81 | ι | 82 | ⋈ | 83 | ⋈ | 84 | ⋈ | 85 | < | 86 | > | 87 | @ | 88 | | 89 | ^ |
| 60 | β | 61 | γ | 62 | δ | 63 | g | 64 | + | 65 | — | 66 | * | 67 | / | 68 | ℓ | 69 | ℓ | 70 | \$ | 71 | = | 72 | | 73 | , | 74 | ° |
| 45 | R | 46 | S | 47 | T | 48 | U | 49 | V | 50 | W | 51 | X | 52 | Y | 53 | Z | 54 | 0 | 55 | I | 56 | 2 | 57 | 3 | 58 | 4 | 59 | 5 |
| 30 | C | 31 | D | 32 | E | 33 | F | 34 | G | 35 | H | 36 | I | 37 | J | 38 | K | 39 | L | 40 | M | 41 | N | 42 | O | 43 | P | 44 | Q |
| 15 | J | 16 | I | 17 | → | 18 | ← | 19 | × | 20 | ± | 21 | ≠ | 22 | ≥ | 23 | ≤ | 24 | ↑ | 25 | √ | 26 | Σ | 27 | ∴ | 28 | A | 29 | B |
| 0 | π | 1 | ⊖ | 2 | Δ | 3 | + | 4 | × | 5 | ⊖ | 6 | 4 | 7 | × | 8 | 7 | 9 | Y | 10 | ⊖ | 11 | * | 12 | × | 13 | ⊖ | 14 | Δ |

APPENDIX

ASD CALCOMP LIBRARY CALLS

Each computer center with graphics capability has a unique software package. No industry standard is available, however, the CALCOMP library, or a derivative, is available at most computer centers. The Digital Datcom Plot Module was written to utilize the WP-AFB Aeronautical Systems Division (ASD) Computer Center CALCOMP software library. In order for the plot module to be adapted to another software package, each of the ASD CALCOMP library subroutines called by the program, as defined in this section, must be replaced by the corresponding references to the new library package. These definitions were taken from the ASD Computer Center CALCOMP Plotter Guide. Along with each subroutine description, the Plot Module subroutines from which it is called and the number of calls in that subroutine are given.

1. AXIS - AXIS DRAWING ROUTINE

Purpose: This routine will draw an axis with tic marks. Each tic mark is annotated and an axis title is drawn.

Calling Sequence:

CALL AXIS (X,Y,BCD,NC,SIZE,THETA, AMIN,DA)

where (X,Y) The coordinates of starting point of the axis, in inches, from the plot reference point (or origin).

BCD - An array containing the title of the axis. This title will be centered along the axis and drawn parallel to it.

NC - The number of characters in the title. If NC is positive, annotation will be on the counter-clockwise side of the axis. If NC is negative, annotation will be on the clockwise side of the axis.

SIZE - The length of the axis to be drawn, in inches.

THETA - The angle of the axis to be drawn (i.e., 0.0 for the X-axis and 90.0 for the Y-axis).

AMIN - The adjusted minimum of a data array. When subroutine SCALE is used, AMIN should be $A(N*K+1)$. See Section 9 of the Appendix for a definition of subroutine SCALE and the array A.

DA - The adjusted value or length of the variable per inch. When subroutine SCALE is used, DA should be $A(N*K+K+1)$.

Comments: Using the array A in the example used for subroutine SCALE, the following call will generate an axis in the X-direction with the proper scale.

```
CALL AXIS (0.,0.,6HX-AXIS,-6,8.,0.,A(81),A(82)).
```

To generate an axis in the Y-direction use

```
CALL AXIS (0.,0.,6HY-AXIS,6,8.,90.,A(81),A(82)).
```

The axis will start at the origin (0,0) and extend 8 - inches in either the X or Y directions with annotated tic marks and labeling.

Plot Module References:

Called from subroutine DRAW in two places.

2. FLINE - CURVE SMOOTHING SUBPROGRAM

Purpose: FLINE draws a smooth curve through an array of points.

Calling Sequence:

CALL FLINE (X,Y,N,K,J,L)

where X - The array of unscaled abscissa values.

Y - The array of unscaled ordinate values.

N - The number of points in the array.

If N is positive this routine will function the same as subroutine LINE.

If N is negative the points will be connected with a smooth curve rather than a straight line. A modified spline-fitting technique is used.

K - The repeat cycle of a mixed array (i.e., the data to be plotted is stored in every Kth cell see Section 11 of the Appendix for a definition of the K parameter).

J - The plot mode designator:

J < 0, Draw a symbol at every Jth point.

J = 0, Connect all points with a straight line or a smooth curve.

J > 0, Connect all points with a straight line or a smooth curve and draw a symbol at every Jth point.

L - An integer specifying the symbol to be used (see Table 3 for the symbols). The integers (0-13) inclusive are the only ones that will produce a centered symbol.

Comments: The X and Y data arrays must be dimensioned at least $(N*K+K+1)$ and the adjusted XMIN, DX, YMIN and DY must be stored in $X(N*K+1)$, $X(N*K+K+1)$, $Y(N*K+1)$, and $Y(N*K+K+1)$ respectively.

Plot Module References:

Called from subroutine DRAW in one place.

3. GRID - GRID DRAWING SUBPROGRAM

Purpose: GRID draws equally spaced horizontal and vertical lines.

Calling Sequence:

CALL GRID (X,Y,DX,DY,M,N)

where (X,Y) - The coordinates, in inches, of the starting point of the grid.

CX - The spacing or distance, in inches, between X grid lines.

DY - The spacing or distance, in inches, between Y grid lines.

M - The number of X grid lines to be drawn.

N - The number of Y grid lines to be drawn.

Comments:

Plot Module References:

Called from subroutine DRAW in one place.

4. LINE - ARRAY PLOTTING ROUTINE.

Purpose: This routine is used to plot an array of points.

Calling Sequence:

CALL LINE (ABSC,ORD,N,K,J,L)

where ABSC - The array of unscaled abscissa (X) values.

ORD - The array of unscaled ordinate (Y) values.

N - The number of points to be plotted from the array.

K - The increment used to select the points to be plotted from the array (see Appendix C, for a discussion of the use of the K parameter). Normally $K = 1$.

J - The plot mode designator:

$J < 0$, Draw a symbol at every Jth point.

$J = 0$, Connect all points with a straight line.

$J > 0$, Connect all points with a straight line and draw a symbol at every Jth point.

L - An integer specifying the symbol to be used (see Symbol Table in Section 6.12).

Comments: The X and Y data arrays must be dimensioned at least $(N*K+K+1)$, and the adjusted XMIN,DX,YMIN and DY must be stored in $X(N*K+1)$, $X(N*K+K+1)$, $Y(N*K+1)$ and $Y(N*K+K+1)$ respectively.

CALL LINE (X,Y,80,1,5,0)

will connect the 80 points defined by the (X,Y) coordinate pairs with straight lines and plot the symbol every 5th point. The scale factors must be located in X(81),X(82), Y(81) and Y(82).

Plot Module References:

Called from subroutine DRAW in one place.

5. NUMBER - A ROUTINE TO DRAW FLOATING POINT NUMBERS.

Purpose: This routine is used to annotate a plot with floating point numbers; it will convert a floating point number to its display code equivalent and draw the number.

Calling Sequence:

CALL NUMBER (X,Y,HGHT,FPN,THETA,N)

where (X,Y) - The page coordinates of the lower left corner of the first annotation character.

HGHT - The height, in inches, of the number to be drawn.

FPN - The number to be drawn.

THETA - The angle of lettering with respect to the X-axis.

N - Decimal character count

N > 0, N is the number of plotted digits to the right of the decimal point.

N = 0, No fractional part.

N = -1, No fractional part and no decimal point.

N < -1, N -1 digits are truncated starting at the units digit.

In all cases, the rightmost digit drawn will be rounded.

Comments: Subroutine NUMBER calls subroutine SYMBOL to draw the actual annotation characters. All size and spacing conventions are the same as SYMBOL.

CALL NUMBER (5.,5.,0.21,53.2326,0.,3)

The preceding call will draw the number 53.233 parallel to the X-axis with the lower left hand corner of the number 5 starting at the page coordinates (5.,5.). Each letter will be 0.21 inches in height with the entire number taking 1.26 inches.

Plot Module References:

Called from subroutine DRAW in nine places.

Called from subroutine DRAW5 in one place.

Called from subroutine DRAW6 in one place.

6. PLOT - PEN MOVEMENT ROUTINE.

Purpose: This routine causes the pen to move from its current position to a new location, which may represent a new origin.

Calling Sequence:

CALL PLOT (X,Y,IC)

where (X,Y) - The page coordinates, in inches, of the point to which the pen is to be moved.

(1) The magnitude of $IC=M+N$

where $M = 2$ for pen down

$M = 3$ for pen up

$N = 0$ if X and Y are physical page coordinates and require no scaling.

$N = 10$ if the scale factors provided through subroutine OFFSET are to be used to compute the pen movement (i.e., convert to physical page coordinates)

$N = 20$ if the buffers are not to be cleared.

(2) If IC is negative, a new plot reference point is established (i.e., after moving to (X,Y) in linkage, assign this point as the new origin). On an off-line system this will also result in writing a new block address record.

Comments: This routine is the workhorse of the plotting package; all incremental plotting commands are generated here.

CALL PLOT(5., 6., 3) Will move the pen from its current position to the point (5., 6.) with the pen up.

CALL PLOT(5., 6., -2) Will move the pen from its current position to the point (5., 6.) with the pen down and will assign this point as the new origin.

Plot Module References:

Called from subroutine DRAW in seven places.

Called from subroutine DRAW5 in two places.

Called from subroutine DRAW6 in two places.

Called from subroutine WAIT in one place.

7. PLOTE - PLOT TERMINATION ROUTINE.

Purpose: This routine creates the necessary instructions to properly terminate plotting. It will print a time estimate for the plot (off-line only), create terminal instruction for the operator, and ascertain that the last buffer or partial buffer has been written.

Calling Sequence:

CALL PLOTE(N)

Comments: This routine must be called after all plotting has been completed. It should appear at the termination of the main program, immediately preceding the STOP statement. The parameter N will contain the number of the last block written on the plot tape.

Plot Module References:

Called from subroutine INPUT in one place.

8. PLOTS - PLOT INITIALIZATION ROUTINE.

Purpose: This routine (off-line only) is used to initialize the CALCOMP plotting package. The routine allocates buffers and initializes all I/O.

Calling Sequence:

CALL PLOTS (DATA,N,M)

where DATA - The starting address of an area of core storage reserved as a work region for the CALCOMP plotting package (this array name must be dimensioned at least N.

N - The number of words in this work region (1024 is optimum).

M - The FORTRAN logical tape number.

Comments: This routine must be called before any other routine if the off-line plotting package is referenced; it should be the first executable statement of the main program.

Plot Module References:

Called from MAIN in one place.

9. SCALE - ROUTINE TO ESTABLISH SCALING VALUES.

Purpose: This routine will find the scale values of an array and adjust them to optimize the plot but maintain reasonable values for the axis annotation.

Calling Sequence:

CALL SCALE (A,S,N,K)

where A - The array to be scanned for minimum values. An adjusted minimum will be stored in A(N*K+1) and an adjusted delta or length of variable per inch will be stored in A(N*K+K+1).

S - The length of axis (in inches) over which the data is to be plotted.

N - The number of points to be scanned in the array.

K - The magnitude of K is the increment by which subroutine SCALE will scan through the array (see Section 11 of the Appendix for a discussion of the use of the K parameter).

Comments: Note that the data array (A) must be dimensioned at at least $(N*K+K+1)$. The minimum selected will not necessarily be the exact data minimum; likewise, the delta selected is limited to 1,2,4,5, or 8 times a power of ten. These selections are made in an attempt to make the axis annotation more legible; however, the nature of the data may be such that it will result in an undesirable compression of the curve. In this event, it should be noted that the use of subroutine SCALE is optional. If the programmer knows the range of his data, he may supply the minimum and the delta himself. This technique is employed when plotting a family of curves, because the same scale factor must be applied to all dependent variables.

DIMENSION A(82)

...

CALL SCALE (A,8,80,1)

Will scan A(1) through A(80) for the minimum value of A. The data will be scale adjusted for an 8-inch axis with the adjusted minimum being returned in A(81) and adjusted delta in A(82).

Plot Module References:

Called from subroutine DRAW in four places.

10. SYMBOL - SYMBOL DRAWING ROUTINE.

Purpose: This routine is used to annotate the plot or draw alphanumeric characters or special symbols.

Calling Sequence:

CALL SYMBOL (X,Y,HGHT,IBCD,THETA,N)

where (X,Y) - The page coordinates of the lower left corner (before rotation) of the first character, for alphanumeric characters. For a special symbol (N is negative) the page coordinates define the center of the symbol. Note that only the first 14 characters (0-13) are centered when using a special symbol. If the integer specifying the special symbol is greater than 16, the page coordinates define the lower left corner of the character drawn.

HGHT - The desired letter height, in inches. For best results, HGHT should be a multiple of seven times the plotter increment size (i.e., $7 * M * 0.005 = 0.035 * M$ for off-line).

IBCD - The array containing the BCD character string or an integer specifying a special character (see Table 3 for the symbols).

THETA - The angle of the lettering with respect to the X-axis.

N - Character count

N > 0, N is the number of characters to be drawn from the alphanumeric array IBCD.

N = 0, One alphanumeric character is drawn.
The display code representation of this
character must be right-justified in IBCD.

N = -1, One alphanumeric character is drawn.
The integer specifying this character
from the symbol table is stored in IBCD.
The pen is also raised.

N = -2, Same as N = -1 except that the pen is
lowered and a line is drawn from the
current pen location to the position
specified by (X,Y).

Comments:

The following rules govern character spacing:

- (1) The width of each letter is $(4/7) * HGHT$.
- (2) The space from the beginning of one letter to the beginning of the following letter is the same as HGHT.
- (3) If a centered symbol (N is negative) is specified, the spacing and width of the character will be the same as HGHT.

CALL SYMBOL (5.,5.,0.21,6HSAMPLE,0.,6)

The preceding call will draw the word "SAMPLE" parallel to the X-axis with the lower left hand corner of the letter S starting at the page coordinated (5.,5.). Each letter will be 0.21 inches in height with the entire word taking 1.26 inches.

Plot Module References:

Called from subroutine DRAW in nine places.

Called from subroutine DRAW5 in one place.

Called from subroutine DRAW6 in one place.

11. USE OF THE K PARAMETER

The parameter K, which defines the data increment in subroutine SCALE and LINE, may be used as follows:

A. To pick out all points in a single dimensioned array, in this case $K=1$.

B. To thin a single dimensioned array; that is, plot every Kth point only. The data array is composed of $N \cdot K$ points. If the original data array contained M points, then $N \cdot K = M$ and the array must be dimensioned at least $N \cdot K + K + 1$ or equivalently $M + K + 1$.

C. To select the most significant part from a double precision array, in this case $K=2$.

D. To select a given variable from a packed array (K =the number of variables in the array). Consider the packed array A:

$A(1) = Y1(1)$

$A(2) = Y2(1)$

$A(3) = Y1(2)$

$A(4) = Y2(2)$

$A(5) = Y1(3)$

$A(6) = Y2(3)$

$A(7) = Y1(\text{min.})$

$A(8) = Y2(\text{min.})$

$A(9) = Y1(\text{delta})$

$A(10) = Y2(\text{delta})$

In this example $N=3$ and $K=2$. It should be noted that, when using a packed array, $K*(N+2)$ cells are required to hold the data and associated scale factors. The following logic might be used to scale this family of two curves:

```
N=3
K=2
NK=N*K
NKK=NK+K
CALL SCALE (A,S,NK,1)
A(NKK+1)=A(NK+2)
A(NKK+2)=A(NK+2)
A(NK+2)=A(NK+1)
```

The programmer should also note that, when plotting a packed array, both the abscissa and ordinate arrays must be packed using the same value of K .